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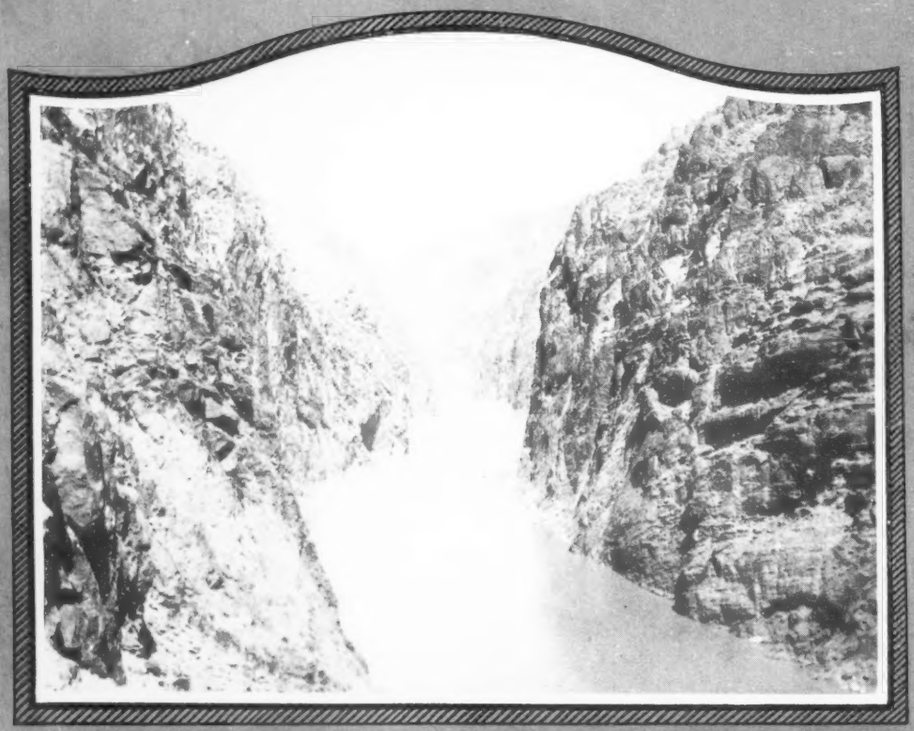

BLACK CANYON SEEN FROM NEVADA SIDE OF THE COLORADO HALF A MILE BELOW THE SITE UPON WHICH THE GREAT HOOVER DAM WILL RISE

Manhattan's Oldest Trust Company in Its Newest Home
C. H. Vivian

Singapore Obtains Increased Water Supply
G. B. Gifford-Hull

Great Lakes and Remote Refineries Linked by Pipe Line
E. B. Weiberg

America's Wonder River—The Mighty Colorado
R. G. Skerrett

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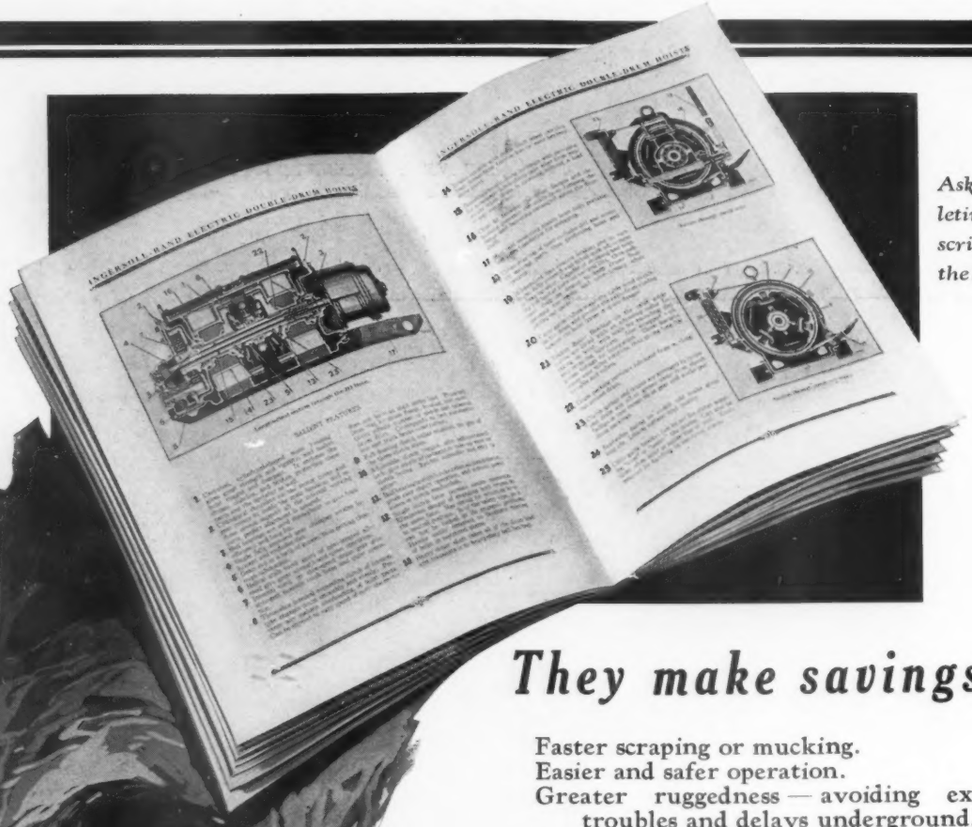
I-R Electric Slusher Hoists

have these

25 features you should know about



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As It Seems To Us

NATION TO HAVE HYDRAULIC LABORATORY

HYDRAULIC laboratories have been in existence in Europe for a goodly number of years. These aids to the engineer have proved of the utmost value in the study, on much reduced scales, of the problems involved in river improvements and many other kindred undertakings. It is therefore gratifying to learn that during the current year there will be ready for service at the Bureau of Standards, in the District of Columbia, what is to be known as the National Hydraulic Laboratory.

In appropriating money for the institution, the Congress specified that the laboratory should be equipped to conduct basic scientific research in hydraulics; to make model tests of hydraulic structures; and to test and to develop current meters and other hydraulic appliances—in fact, cover all phases of hydraulic engineering.

One has only to recall the steadily augmenting number of hydro-electric plants, efforts to redirect for man's benefit the courses and channels of rivers, and the urgent need of water conservation and flood control to realize how important a part a hydraulic laboratory could play in pointing the way to effective and economical solutions of the physical puzzles presented by existing conditions and contemplated correctives. Undoubtedly, the new laboratory will do in its field what model-experimental basins have done in the dual realm of naval architecture and marine engineering.

HOW CAME COAL

COAL is so common a commodity and so familiar to all of us that we accept it as a matter of course. We know that coals differ in appearance and in their physical and chemical properties; but beyond that relatively few of us ponder how coal came into being. Nevertheless, the topic is one of recurrent interest to scientists; and even today there is disagreement among them as to how nature caused coal to form and to evolve into the different kinds now put to use by man.

Two of the German participants in the recent coal conference held in Pittsburgh renewed the controversy concerning the origin of coal. According to a widely accepted theory, all coal was once vegetal matter and, because of the conditions to which it was subjected, became successively peat, lignite, bituminous coal, and, finally, anthracite. Dr. ERNEST BERL, a chemical engineer, disclosed how it has been found possible in the laboratory to create from cellulose a substance that meets the tests ordinarily applied to gas-making and cooking coals. His *confrére*, Dr. FRANZ FISCHER, director of the Kaiser Wilhelm Institute for Coal Research, earnestly contended that nature's coal did not evolve from cellulose but from the residues left of plant life after the cellulose had been destroyed by bacteria. Doctor FISCHER was equally emphatic in declaring that even if a product could be made in the laboratory which would resemble natural coal in every way, still it was no proof that nature had followed a similar process in creating coal. In short, Doctor FISCHER stood for the generally accepted theory of the genesis of the familiar fuel. General interest in the subject will probably not lead the public to take sides. To most of us coal is just coal.

LET OUR PAST GIVE US CONFIDENCE

BATTLES won justify confidence in facing new contests. Accepting this truism, the people of this country should not lack courage to go forward cheerfully in pursuit of that prosperity which they think has deserted them. Let what their forebears have done in kindred circumstances hearten them now.

The conditions confronting us today differ mainly in degree from those that have beset us in the past; and point is given to this by an editorial—singularly apropos at this moment—that appeared in *Harper's Weekly* in October of 1857, now more than 74 years ago. Let us quote at some length:

"It is a gloomy moment in history. Not for many years—not in the lifetime of most men who read this paper—has there been so much grave and deep apprehension; never has the future seemed so incalculable as at this time. In our own country there is universal commercial prostration and panic, and thousands of our poorest fellow-citizens are turned out against the approaching winter without employment, and without the prospect of it.

"In France the political caldron seethes and bubbles with uncertainty; Russia hangs as usual, like a cloud, dark and silent upon the horizon of Europe; while all the energies, resources, and influences of the British Empire are sorely tried, and are yet to be tried more sorely, in coping with the vast and deadly Indian insurrection, and with its disturbed relations in China.

"It is a solemn moment, and no man can feel an indifference—which, happily, no man pretends to feel—in the issue of events. Of our own troubles no man can see the end. They are, fortunately, as yet mainly commercial; and if we are only to lose money, and by painful poverty to be taught wisdom—the wisdom of honor, of faith, of sympathy, and of charity—no man need seriously despair. And yet the very haste to be rich, which is the occasion of this widespread calamity, has also tended to destroy the moral forces with which we are to resist and subdue the calamity.....

"Good friends! Let our conduct prove that the call comes to men who have large hearts, however harrowed their homes may be; who have open hands, however empty their purses."

In 1857 we were a nation of about 31,000,000 souls: today we number substantially 123,000,000, and we are correspondingly richer in all the material things of life. Surely, we have no reason to be dismayed by the conditions confronting us—they have been many times worse in the decades gone. Let us start the new year with confidence born of what we have done before.

PLIGHT OF NUT PICKERS CLEW TO VANISHED TRIBES

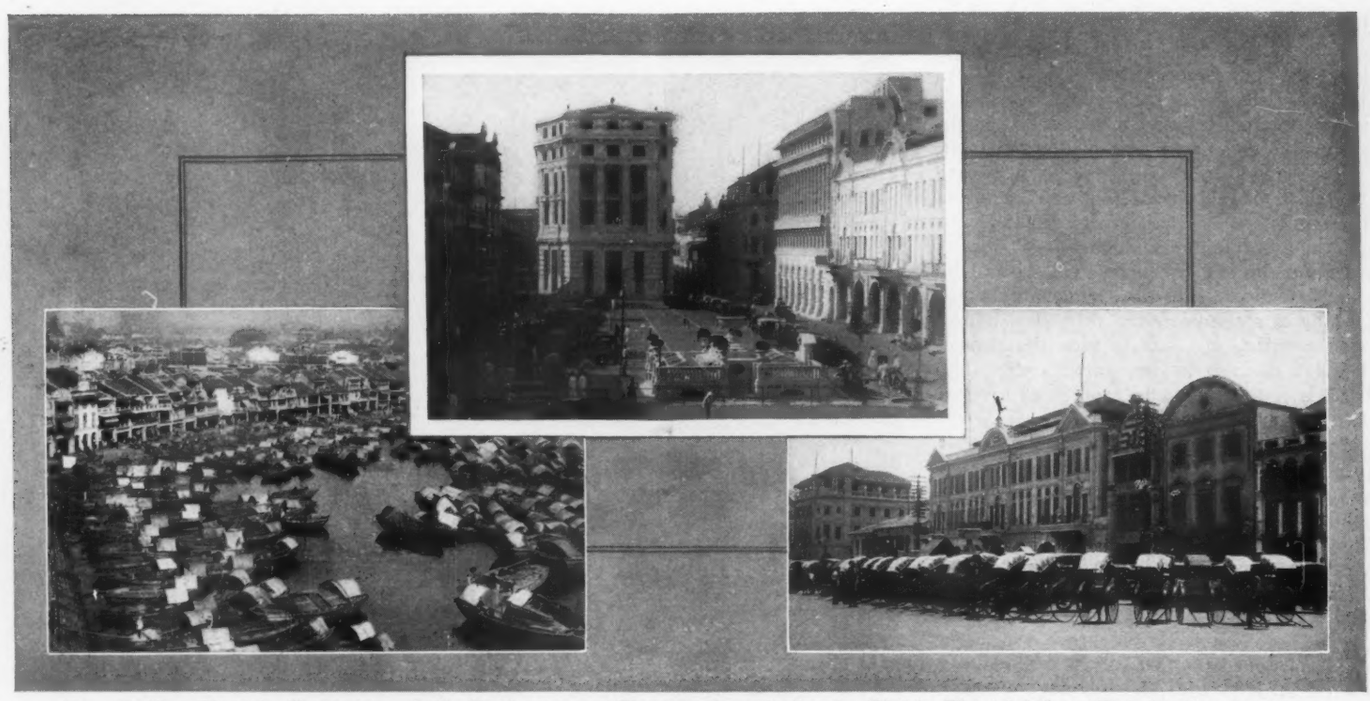
MUCH concern was manifested a short while back for Navajos and Zunis that were marooned for a week or so on the mesas of New Mexico by sudden and violent snowstorms. The Indians had gone upon their annual quest for pinon nuts, which are fit for gathering only after they have been touched by frost. The harvest promised to be an abundant one, and both men and women of the tribes were at work picking the nuts, for which there is a ready and profitable market. About 1,300 of them were so engaged when snow and cold enveloped them. More than likely the lives sacrificed will not exceed a dozen, and this happy outcome of a desperate predicament is due to the enterprise of white men and to the prompt action of the Federal Government.

Before relief reached the Indians there was apprehension lest all the snow-bound nut hunters should perish, and the situation revived speculation about what had caused the wholesale disappearance of the Indians who had once inhabited the cliff dwellings of the region. Their extinction has occasioned the advancement of many theories, and the problem was complicated by the fact that no skeletal remains have ever been discovered although there are ample evidences that the dwellings were occupied and even suddenly deserted while fires were burning beneath cooking vessels. This all occurred, so archaeologists compute, about 600 years ago.

The recent predicament of the Zunis and Navajos is now believed to shed light on what may have happened about 1300 A. D. That is to say, the Indians then perished by unexpected snowstorms that caught them unprepared on some of the mesas while far from their dwellings on a food quest. Possibly the Indians that had remained behind died in a similar way when seeking to find and to succor their snow-bound relatives. Thus the happening of a few weeks ago may explain away a mystery that has long puzzled our archaeologists.

Keystone View Company

NEW York greets the New Year with the world's tallest structure. May this symbol of courage, enterprise, and achievement, be also an inspiration to our readers. May they, by their own energies, by their will to do, surmount all obstacles in their several paths and find 1932 a happy and prosperous year.



Top—Raffles Place in Singapore. Left—Boat quay on Singapore's waterfront. Right—The 'rickshaw still holds its place as a vehicle in Singapore.

Singapore Obtains Increased Water Supply

Projects Lately Carried to Completion are Counted Upon to Assure that Port Ample Water for the Next Two Decades

By G. B. GIFFORD-HULL, O. B. E.*

NOT without reason, Singapore is called the "Crossroads of the World". There it is that ships traversing the far-flung waters of the Orient almost always pause no matter how their routes may diverge after passing the tip of the Malay Peninsula. Writers of nautical tales have made much of the colorful atmosphere of this typically far-eastern port. But Singapore is more than a fruitful source of inspiration to the romancer—it has an extremely practical place in the annals of maritime commerce. Thousands and thousands of craft use Singapore annually for purposes of trade, and it is computed that the value of this business amounts yearly to something like $1,000,000,000.

Singapore, the city, is situated at the southern end of Singapore Island—the largest of the group constituting what is known as the Straits Settlements. The island is 27 miles long and fourteen miles broad, and is separated from the mainland and the nearby native State of Johore by a narrow body of water of not more than half a mile in width. This insular possession was ceded to the British by the Johore princes in 1819; and what it has developed into in the interval is entirely due to the enterprise of Great Britain. It was virtually uninhabited when ceded. Only so recently as 1901, the population, a decidedly composite one, totaled 228,555. Today the population numbers about 550,000; and the vast majority is made up of emigrant Chinese, Malays, and Indians.

As is so generally the case with rapidly increasing communities, the problem of an ample supply of water for domestic and industrial purposes is a pressing one, and Singapore is no exception to this rule. The climate of the region is a decidedly humid one, and year in and year out there are something like 180 rainy days. The principal difficulty has lain in the lack of catchment basins large enough on the Island of Singapore to retain enough of the precipitation to meet the municipal needs. The consumption of water at the present time is about 17,000,000 gallons per diem. Up to 1928, Singapore was supplied from two reservoirs on the island—one of which was completed in 1912.

Between 1919 and 1923, surveys were made for the purpose of locating additional sources of water, because the growth of Singapore made it evident that water on the island would not be adequate after 1929. As a result of those investigations, what are known as the Gunong Pulai and the Pontian schemes were adopted. This article describes the steps taken in carrying out these projects, which will give Singapore a daily supply of water in excess of 30,000,000 gallons.

Drilling rock with an ever-handy "Jackhamer".

The watershed drawn upon lies on the slopes of Pulai Mountain, in the State of Johore, about 40 miles from Singapore; and four streams are the immediate sources of the water. These are: Pulai II and Pulai III, both of which flow southward; and Pontian Kechil and Ayer Hitam, flowing, respectively, southwest and westward. Pontian Kechil has the largest catchment area—a matter of 3,000 acres.

The first section of the scheme em-

*Member, Institute Civil Engineers and American Society Civil Engineers.

braces Pulai II and Pulai III; and the works consist of the Gunong Pulai Dam, 600 feet long and 120 feet high, built across Pulai II, and of the Col Dam, 340 feet long and 30 feet high, erected across a depression in the ground at the upper end of the reservoir. These dams form a basin capable of holding 1,220,000,000 gallons and known as the Sultan Ibrahim Reservoir—named after His Highness the Sultan of Johore. This reservoir obtains its water directly from the Pulai II and its small tributaries, and also from the Pulai III by way of a tunnel driven through a hill—a weir diverting the stream into the tunnel. The hill divides the two catchments. The basin is counted upon to provide an average daily supply of 6,500,000 gallons.

In addition to the foregoing features, this project includes an installation of aeration and sedimentation tanks, together with mechanically operated filters that can treat 18,000,000 gallons every 24 hours. There is also a steel pipe line, 36 inches in diameter and 33 miles long, linking the filters with Singapore. Finally, there is a covered service reservoir, at Fort Canning in Singapore, which has a capacity of 30,000,000 gallons. Work was started in 1924 with the building of headworks at Gunong Pulai and the construction of the pipe line.

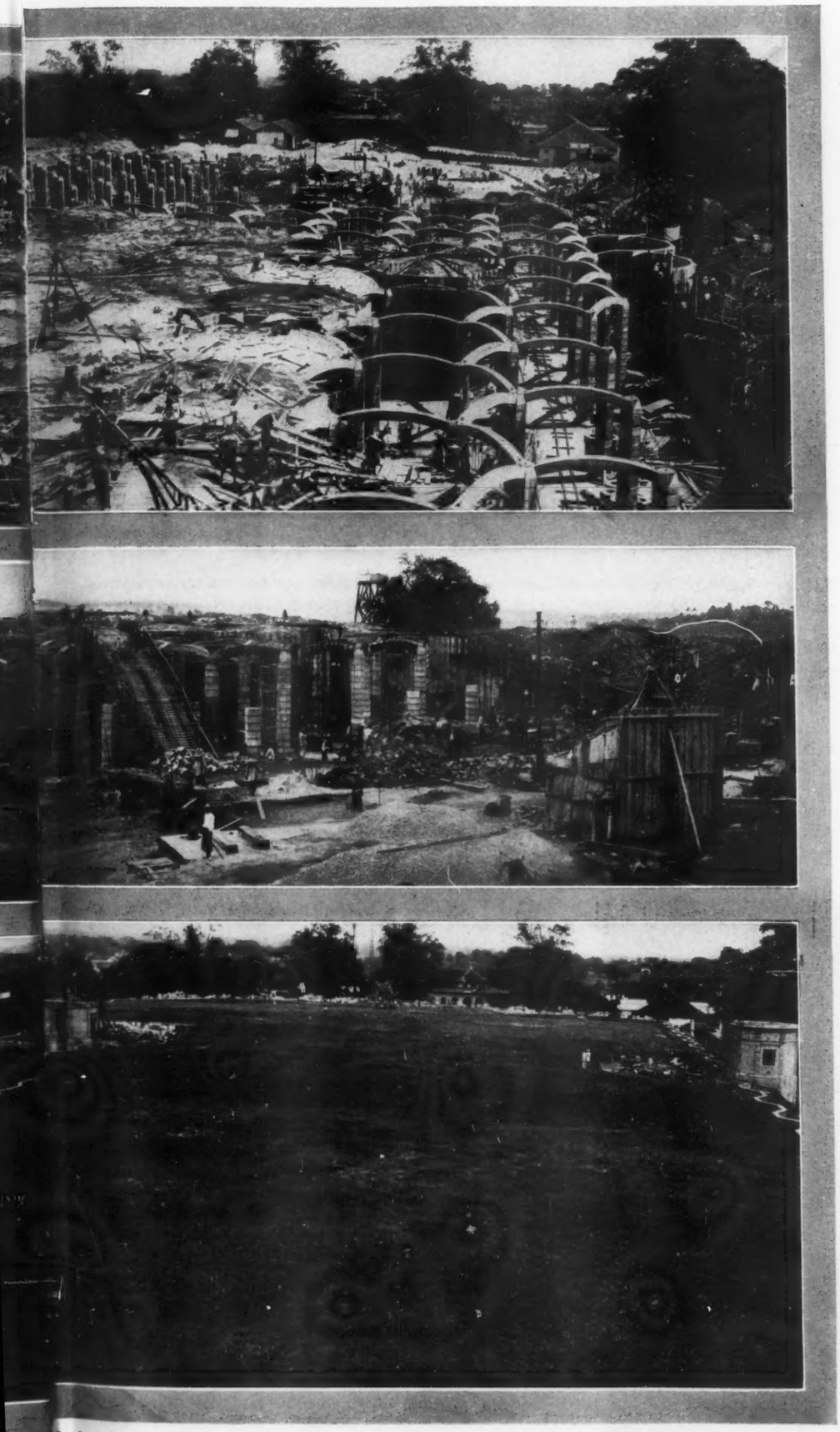
An access road to the site had to be built before the headworks could be undertaken. It was necessary to clear the jungle; to make extensive antimalarial provisions; and to call into being coolie lines for 1,500 men and accommodations for the European staff. A filtered water supply was installed for the whole camp, as well as sprinkler filters for the treatment of sewage. Hospitals, stores, workshops, and a police station and quarters were provided. These preliminaries were completed in 1925, and actual construction on the project was begun in the same year.

An excellent foundation for the Pulai Dam was uncovered by the removal of 94,000 cubic yards of earth. The dam, built of concrete and of gravity section, is faced with granite masonry on the upstream and downstream sides. It has a spillway in the center; and on the upstream side there is a masonry valve tower containing the inlet pipes and valves which control the flow of water to the filters.

Stone for concrete and for facing the dam was obtained from various moderate-sized deposits situated about a quarter of a mile from the site. Four crushing plants furnished the stone for concrete. The facing blocks of granite for the main dam were cut by the plug-and-feather method from large granite boulders, some of which weighed as much as 700 tons. Cement was transported by water from Singapore to Scudai, a distance of 23 miles, where two unloading jetties and a storage shed were constructed. The cement was moved from Scudai to the dam, thirteen miles away, by motor trucks. Sand was obtained from the river above and below the dam site. Despite the restricted site and other hampering conditions, the Pulai Dam was completed before the end of 1928, about the same time as the Col Dam.

The tunnel connecting the catchments of the Pulai II and the Pulai III streams was

Fort Canning Reservoir, in Singapor



during various stages of construction.

driven from both ends, and was finished in June 1928. It pierced material ranging all the way from solid granite to quicksand. In soft ground the tunnel is lined with steel segments, and inside of the steel there is a concrete lining 6 inches thick. Where so lined the tunnel has a net diameter of 4 feet 11 inches; and where it passes through quicksand it has an additional thickness of 1 foot of concrete placed outside of the steel. In the rock section only the floor and half of the sides are lined with concrete. The concrete diversion weir, which leads the water into the tunnel from the Pulai III, is 120 feet long, 20 feet high, with a concrete cut-off trench on the upstream side 100 feet from the dam. These are connected by a reinforced-concrete apron.

The pipe line was divided into two sections of about equal length: one on the mainland and one on Singapore Island, and both were constructed concurrently. The conduit is laid in part through a hilly jungle, in part across swamps, and considerable of it across cultivated lands. It is supported on concrete piers, resting on piled foundations, where it traverses swamps. The line was available for service in 1927, and was used to bring raw water from a temporary intake on the Pulai II to one of the existing reservoirs on Singapore Island.

The use of slow sand filters being precluded by land restrictions, Paterson rapid-gravity, mechanically cleaned filters were chosen. The filtration plant consists of a 5-story chemical house containing engines, pumps, air compressors, alum tanks, a lime mill, etc., and of a filter building three stories high. This structure houses the filters at the top and a clear-water tank of 1,000,000 gallons capacity at the bottom. These facilities were made available in 1929, and Singapore has been receiving filtered water ever since from that source.

The Fort Canning service reservoir is a reinforced-concrete structure built at the top of Fort Canning Hill, Singapore. It is about 800 feet long, has an average width of 300 feet, a depth of 30 feet, and can store 30,000,000 gallons of water. The roof consists of 264 domes carried on hexagonally arranged columns. The reservoir is built partly in the ground and partly out of the ground, and the side walls are a series of vertical arches and buttresses so designed that they can take stresses either from the ground or from the water within. This structure was finished by the end of 1928.

The Pontian project consists of two dams which are of earth supported by concrete core walls. The dam across the main Pontian stream is 65 feet high and 450 feet long; and the dam erected across a depression at the southern end of the valley is 45 feet high and 2,900 feet long. Together, they form a water storage that covers 558 acres and is capable of holding 3,200,000,000 gallons. This undertaking is known as the Farrer Reservoir, and is named after Mr. R. J. Farrer, M.C.S., C.M.G., who was president of the Municipal Commissioners from 1919 to 1931. The reservoir will supply an average of 9,000,000 gallons daily. There is a station equipped with pumps that can handle 18,000,000 gallons per diem against a head of 340 feet. A steel pipe line,

30 inches in diameter and 3½ miles long, links the Pontian development with that of the Pulai.

Both dams have been designed with flat slopes on the upstream side, starting at 4 to 1 at the bottom and finishing at 3 to 1 at the top. The downstream slopes are 2½ to 1, with a flat berm about midway up. There is a stone toe in each of the downstream slopes and another at the end of the upstream slope of the main dam. The outer half of the downstream part of the bank is, in each case, laid on 2 feet of rubble in order to provide drainage and to prevent a high line of saturation. Each of the dams is pitched on the upstream side with granite 15 inches thick laid on 3 inches of broken stone.

The plans of the main dam specified that the core wall go down to rock, while the core wall of the sub-dam did not have to be carried more than 15 feet into the ground. From that point downward, 40-foot Universal steel piles form the remainder of the cut-off. The spillway of the main dam consists of an overflow shaft with a bell-mouthed top 50 feet in diameter. This shaft communicates with the tunnel that rounds the main dam. The tunnel has served the purpose of diverting the river during the building of the dam and will be the spillway during flood-water periods. It is ultimately to be closed at its inlet side by a concrete diaphragm or plug through which two 36-inch scour pipes will be run. The other spillway is on the sub-dam, and will be available during exceptionally high run-offs. This spillway is made up of a series of weirs forming compartments that are partly filled with rubble. These will act as stilling ponds to break the velocity of the spill.

As in the case of the Pulai development, operations on the Pontian project could not be started until after a lot of preliminary work had been finished. This involved building an access road, clearing the jungle, constructing a camp with coolie lines and quarters for the staff, providing a water-supply system, a sewage-disposal plant, a hospital, and workshops, as well as taking antimalarial precautions.

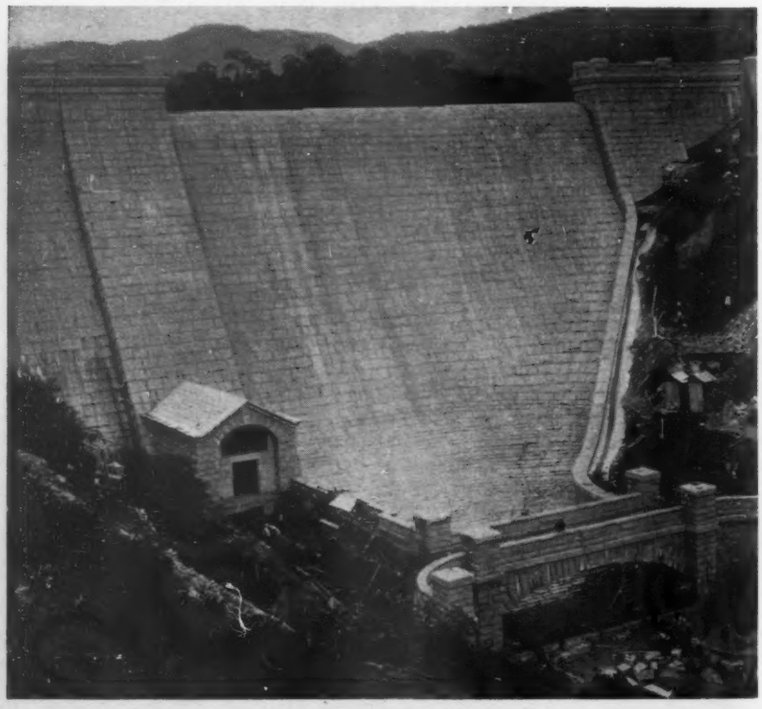
Stone face of main dam of the

The sub-dam site was a swamp. Even after partway draining by the cutting of the antimalarial ditches, it was not possible to dry out more than the top 4 feet of the ground. Below that was encountered soft black mud containing pockets of sand that varied considerably in extent. The weight of the concrete core wall is such as to exert a pressure of approximately 3 tons a square foot. This was more than the sodden ground could safely support; and it was therefore decided to resort to the use of steel piling. This, however, was not done until after it had been determined by experiments just what would be required to carry that burden.

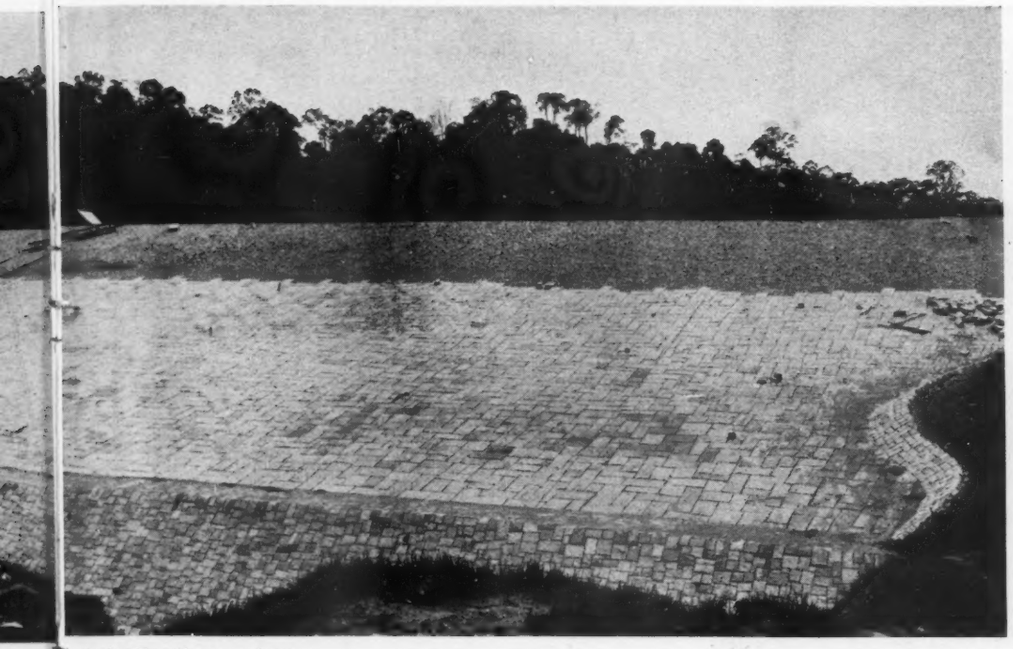
All in all, substantially 2,000 tons of piling was driven; and it provides a factor of safety of 3 against the concrete slipping over the tops of the piles, a factor of safety of 3 against the core wall pushing the piles further into the ground, and a factor of safety of 1½ against the concrete crushing—assuming that the entire weight of the wall were carried on top of the piles, which, of course, is not the case.

When first driven, the tops of the piles remained a few feet above ground; and not until after the trench for the base of the core wall had been excavated were they driven to their final depth. By following this procedure it was possible to avoid leaving a long stretch of open trench that would have to be pumped out up to the time of pouring the base of the core wall. Eventually, when the trench had to be dug to its full depth of 15 feet, water had to be pumped out continually. To make the sloppy bottom of the trench fit for the pouring of concrete, large stones were packed in the excavation to resistance. This squeezed the mud up through the stones. When it was scraped off, a suitable surface was provided for the first lift of concrete. Above ground the core wall was poured in 7-foot lifts with box-shaped construction joints.

Earth for the dam, amounting to 450,000 cubic yards, was dug in a borrow pit about half a mile from the dam and was transported to the site in 3-cubic-yard cars hauled by locomotives on a 3-foot gage track. Fordson tractors, run over the newly spread material, consolidated the earth satisfactorily under



Downstream face and central spillway of the completed Pulai Dam.



n dam of the Pontian project.

conditions that would have prevented the use of a steam roller. By the time concrete was brought up to ground level, the tunnel around the dam had been completed and the river diverted into it. It was then practicable to go right ahead with the dam, itself. The tunnel before lining, had a diameter of 16 feet. It was lined with steel segments enveloping concrete made up of segments 1 foot 6 inches in thickness. The tunnel penetrated ground ranging from fairly soft to rock formation.

The associate pumping station is a reinforced-concrete building 160 feet long and 80 feet wide, with a wet well 40 feet deep and 15 feet wide running the full length of the building. This well connects with the reservoir by means of a concrete intake culvert, 900 feet long, joining two intake towers in the reservoir. In one of the towers are the control valves. The pumping plant is made up of eight Hathorn Davey pumps each of 3,000,000 gallons capacity every 24 hours. The pumps are driven by Crossley Premier gas engines, each of 360 hp. Ultimately there will be two pumping mains, but only one is now being laid. Rock for the concrete work was obtained from a nearby quarry.

A central compressor plant in the large quarry at Pontian, consisting of a 610-foot oil-engine-driven unit, supplied operating air for the tripod drills, the "Jackhamers", the drill sharpener, the oil furnace, and the pedestal grinder required for the work. All concrete in the Gunong Pulai dam was tamped by means of numerous pneumatic tampers, and air to drive those tools was furnished by a battery of portable compressors. The portables also provided compressed air for the "Jackhamers", used in the quarry and in roughing the surface of concrete before pouring succeeding lifts, and for grouting the main dam. Air-driven clay diggers did excellent work in some of the excavating of the Pontian diversion tunnel.

Construction on the second half of this important water-supply scheme was started in 1928, and was scheduled to be finished by the end of the year just closed. The total cost of the undertaking has been estimated at $22,000,000; and the additional water, with the existing island supply, is counted upon to meet Singapore's requirements for the next twenty years. The consulting engineers have been Messrs. Sir Alex. Binnie, Son & Deacon, of London; and, except for the pipe line, the works have been carried out under them by direct administration.

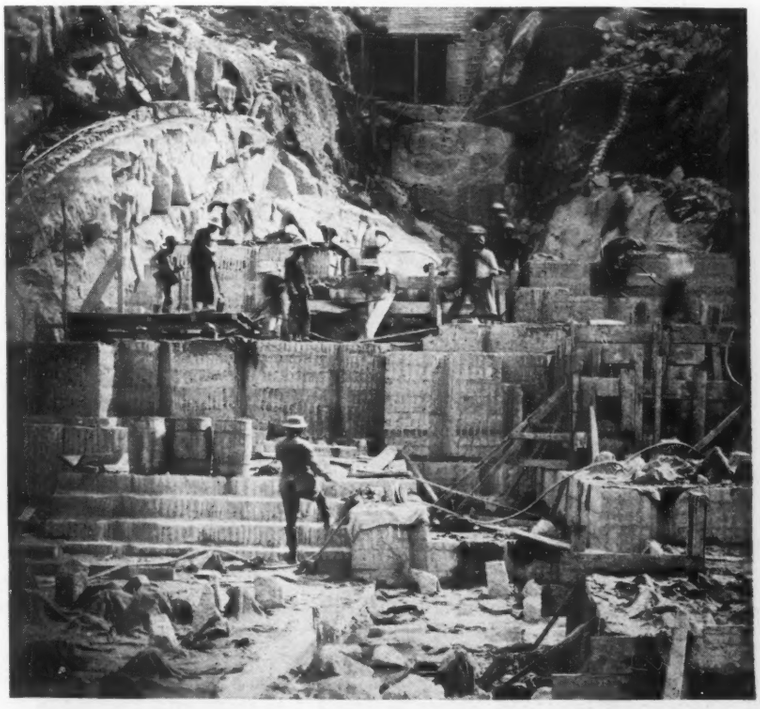
INSULATING MATERIALS FOR THE HOME AND HOW TO APPLY

HOME owners or prospective builders should be interested in a bulletin lately published by the National Committee on Wood Utilization entitled, *House Insulation: Its Economies and Application.* In its compilation the committee has had the assistance of a group of eminent authorities on building and housing headed by LeRoy E. Kern, of Washington, D. C., representing the American Institute of Architects.

Although the committee is interested primarily in the utilization of insulating materials made of wood fiber, so as to put to use trees that would otherwise be wasted, the booklet is comprehensive in its scope. It deals with the history of insulation in man's attempt to keep warm in winter and cool in summer; tells how to apply all kinds of insulation; gives approximate cost tables for insulating various types of houses; and also sets forth comparative fuel savings resulting from the employment of insulation in typical dwellings in different parts of the country.

At a cost of ten cents the bulletin may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Lovers of trees will be gratified to learn that an improved type of electric transmission wire or cable has been developed for use in residential districts so as to obviate the extensive cutting out of foliage. The new tree wire is the product of the General Electric Company, and is available for 600-, 2,500-, 3,500-, 5,000-, and 7,500-volt service. It is highly resistant to abrasion caused by swaying trees, is weatherproof, and easy to splice.



Air tools roughed surfaces before each lift of concrete was poured.

Sections of the line on skids and ready for the bell-hole welder.
Left—At work with an R-39 drill along a rocky stretch of the right of way near Okmulgee.

Vast Pipe-Line System Li Refiners wit G

THE construction of pipe lines for the transportation of natural gas, crude oil, and gasoline reached a high peak in 1930. According to estimates, there were finished or undertaken during that twelvemonth a total of 20,500 miles of such lines—14,000 miles for the delivery of natural gas, 3,500 miles for crude oil, and 3,000 miles for gasoline, involving an expenditure of approximately $500,000,000.

One of the major projects was that of the Great Lakes Pipe Line Company for the construction of a gasoline line from Oklahoma to Chicago and other points in the Great Lakes region. The company was organized to provide the Mid-Continent refineries with a ready means of getting their product to market, and is controlled by the Continental Oil Company, the Barnsdall Refining Company, the Skelly Oil Company, the Pure Oil Company, Phillips Petroleum Company, and the Mid-Continent Petroleum Company.

The contract for the first section of the main line from Ponca City to Barnsdall, Okla., and thence on to Kansas City, Mo., was awarded to the Sheehan Pipe Line Construction Company, of Tulsa, Okla.; and on January 16, 1931, about 6½ months later, the first shipment of gasoline was pumped through that part of the system. As rapidly as possible contracts were let for the remaining sections, as follows: Kansas City to Des Moines, Iowa, the Natural Gas Engineering Corporation, of Tulsa; Des Moines to Minneapolis, Minn., William Schmit; Des Moines to the Mississippi River, the Cater Construction Company of Kansas City; and the Mississippi River crossing and the extension of the line to Chicago, the Seybolt-Mitchell Company, of Houston, Tex. In addition to the main line, branches were run from Barnsdall south to Tulsa, Okmulgee, and Muskogee. The laying of the laterals was the work of the Southwestern Construction Corporation of Tulsa. All these contracts called for the handling of close on to 1,500 miles of 8-, 6-, and 4-inch pipe.

Pump stations have been built along the far-flung system at 50-mile intervals. Each is equipped with two 330-hp. Diesel engines connected to 5¾x24-inch duplex pumps by means of flexible coupling; two 25-kw. generators connected to the pump shafts; a Type Twenty compressor driven by a 7½-hp. motor; a 15-kw. auxiliary generator unit; lubricating oil coolers, and two traveling cranes. Also at each station are large working tanks as well as 80,000-barrel storage tanks for regional distribution. Contracts for all the stations in Oklahoma and Kansas were awarded to J. W. Whitehurst, of Ponca City, and to Bass & Sons, of Enid, Okla., while those north of Kansas City were constructed by the McKee Construction Company of Cleveland, Ohio.

The steps involved in the laying of a pipe line of such length will be interesting to many. To begin with, a survey of the proposed route must be made. If it traverses rough and rocky country the workers are apt to encounter natural obstructions that must be avoided. This may mean additional mileage to be covered—an item to be considered in estimating construction costs. After the route has been selected the right of way must be bought; and this, as may be expected, often requires much diplomacy on the part of those entrusted with that phase of the undertaking.

As soon as that is accomplished, the brush gang or right-of-way gang starts out. It is the duty of these men to remove all brush, trees, or other similar obstacles; to build gates at points in fences where the line passes beneath them; and to make all necessary preparations for the equipment that follows in their wake. The pipe sections are then hauled from the nearest railroad point on trucks by the stringing crew and laid alongside the cleared right of way. Next comes the line-up gang, and its task is to lay from five to six lengths of pipe in a straight line, end to end, on a 4x4-inch wooden skid in readiness for the "firing line" or welders who tie them together into a single section.

After the firing line has got under way, the ditching machines begin their work of digging a trench of sufficient depth to provide from 24 to 30 inches of cover for the pipe. Rocky stretches along the route are jumped by the ditcher and taken care of by rock drills and portable compressors. In the case of the Great Lakes pipe line, many miles of

After the bell-hole welder has finished his work the pipe is ready for lowering.
Right—Hauling a portable through a particularly rugged stretch of country.

Links Mid-Continent Great Lakes

By E. B. WEIBERG

solid rock were encountered near Barnsdall by both the Sheehan Pipe Line Construction Company and the Southwestern Construction Corporation. In shooting a rock section a "pipe liner" does not consider powder costs, but he avoids all hand labor possible. Holes are therefore loaded heavy, and the ditch is cleaned, as far as it is practicable to do so, by the shot. Hand labor is used to clear up after the blast and to prepare the trench for the pipe.

But before the piping can be lowered into the finished ditch the separate sections that have been joined by the welders must be bent to conform to the contours of the trench. This work is done by the bending crew that also places them on skids over the ditch. In that position the pipe lengths are welded into one continuous string by the bell-hole welders. Now the pipe is ready for lowering, which is done as follows.

Since the line breaks only when it is under tension it is necessary to have it at all times under compression. This is accomplished by holding a length of the pipe out of the ditch at a central joint and lowering and backfilling at either side of the bow. The slack thus obtained is then "lowered in". This puts the line under compression and allows for its contraction in cold weather. The work of the bending gang and of lowering-in is done by the aid of tractors equipped with side booms and winches. Backfilling of the trench completes the job.

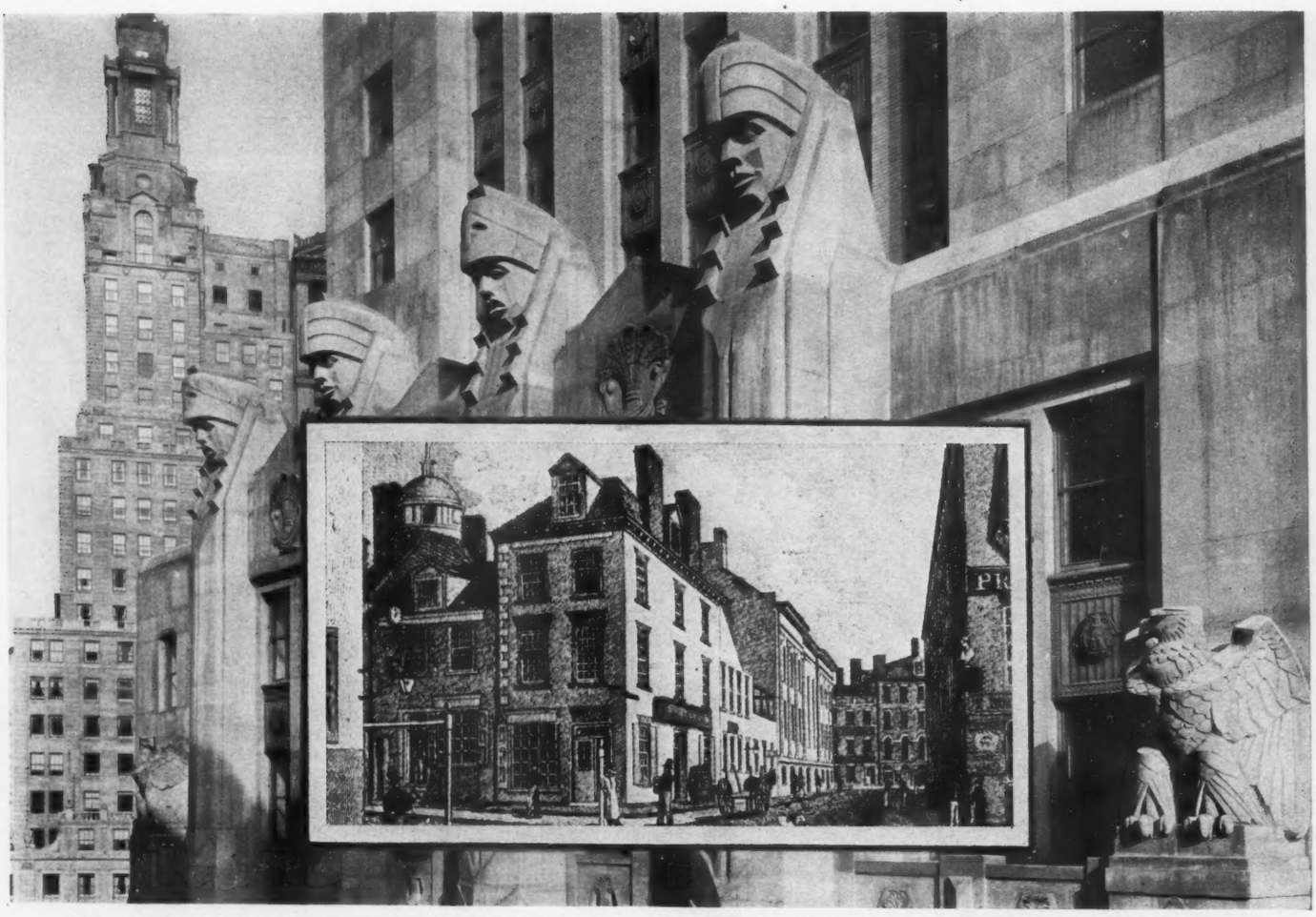
Each contractor has a river-crossing crew for carrying the pipe line across waterways. In laying the Great Lakes line, for example, two small streams and three sizable rivers had to be negotiated. To do this without inviting difficulty, the line is looped far enough upstream so that it will be impossible for the bow to be forced through a turn and to swing downstream. In this manner the pipe is put under compression by the stream; and no breakage will occur unless the bow settles sufficiently to swing downstream.

The use of portable compressors has done much to speed up many phases of pipe-line construction. In addition to rock drills and the indispensable drill-steel sharpener, air-operated paving breakers and clay diggers do effective work in trimming up ditches after shooting. On long gas lines, pneumatic tools serve to clean the pipe preparatory to applying the necessary priming coats by means of the air spray; and air motors are employed to turn the pipe when it is given its hot top coat that protects it against corrosion. Backfill tampers are required in making road crossings; and other lesser pneumatic tools come in handy for repair work of different kinds. In fact all the equipment used with portable compressors finds a ready application in pipe-line construction.

The main line of the Great Lakes system has a diameter of 8 inches and moves approximately 25,000 barrels of gasoline each day. It is estimated that more than 250,000 barrels of gasoline will be required to fill the line in its entirety, including branches that are subsequently to be run to Omaha, Nebr., and to Milwaukee, Wis. The building of these laterals will add considerably to the monetary outlay already involved.

Photos, Charles Latere, New York

The dominating 54-story building of the City Bank Farmers Trust Company.



Stone heads of heroic size adorn the eighteenth floor of the building. Insert—Corner of William Street and Exchange Place about the time the Farmers' Loan & Trust Company was founded more than a century ago.

Manhattan's Oldest Trust Company In Its Newest Home

By C. H. VIVIAN

RISING from historic ground that has undergone almost continual change during the 300 years that it has been occupied, the new City Bank Farmers Trust Company building thrusts its white, stone-encased tower 54 stories into the air in the financial district of New York City. It is the fourth highest office building in the world, and is ranked as one of the most beautiful of the many outstanding structures on Manhattan Island.

Six thousand persons make this building their daytime abode. Several times this number pass in and out of it in the course of a business day. Round about it flows a steady stream of humanity, bent upon the manifold business missions which enter into the life of this teeming corner of the Metropolis. From atop its highest floor, 745 feet above the sidewalks, the eye can take in the panorama of the world's largest port, the gateway to the United States, the bottle neck of American commerce, and the financial capital of the world.

The City Bank Farmers Trust Company, owner of the building, was formed in 1929 through a union of The National City Bank of New York and the Farmers' Loan & Trust Company. The National City Bank dates from 1812. It was founded as the successor to Alexander Hamilton's First Bank of the United States when that institution's charter expired. The trust company was the first organization of its kind in the United States, and probably the first in the world. It was founded February 28, 1822, under the name of the Farmers' Fire Insurance & Loan Company. The fire-insurance business was discontinued in 1835, and in 1836 the charter was amended to change the name to the Farmers' Loan & Trust Company. That company conducts only a trust business, the care and management of the property of its clients; and its activities are so vast as to require a goodly portion of the new structure for offices.

The new building occupies a triangular plot of ground bounded by William, Beaver, and Hanover streets, and by Exchange Place. Tymen Jansen, a ship carpenter for the Dutch West India Company's colony, was the first known tenant of the ground. New Amsterdam was then but a village, with a fort to protect it from the Indians and a wall extending along what is now Wall Street. Jansen received a deed to the property in 1643; but it is probable that he settled there as early as 1624. He built a comfortable home, with truck and flower gardens and a pond where his children played on a raft of their own making.

During succeeding years there were many changes in the tenancy of the site. The list of those who lived there contains many illustrious names. Others were celebrated, if not illustrious. For example, Capt. William Kidd had a coach house there at one time. Gradually, as the city grew, the neighborhood changed in aspect from residential to commercial. For a brief period, at least, it was a favored shopping district for women. With

Left—Stairway that leads from a rotunda to the company's main banking room and private offices. Center—Beautifully carved stonework characterizes the Exchange Street entrance to the building. Right—This fine vaulted hallway is one of the outstanding architectural features of the newest home of New York's oldest trust company.

further growth, New York came to designate the section as the financial center.

In 1882 the Farmers' Loan & Trust Company acquired some of the property and erected upon it a building 2½ stories high. Seven years later, adjoining lots were purchased and a new building was constructed. In 1909, after taking over three additional lots, the company again built—this time a little more pretentiously. This structure—whose cost of $1,476,037 is only a fraction of the sum the present building represents—housed the company until shortly after its affiliation with The National City Bank, when plans were drawn for the modern home which the combined organization now occupies.

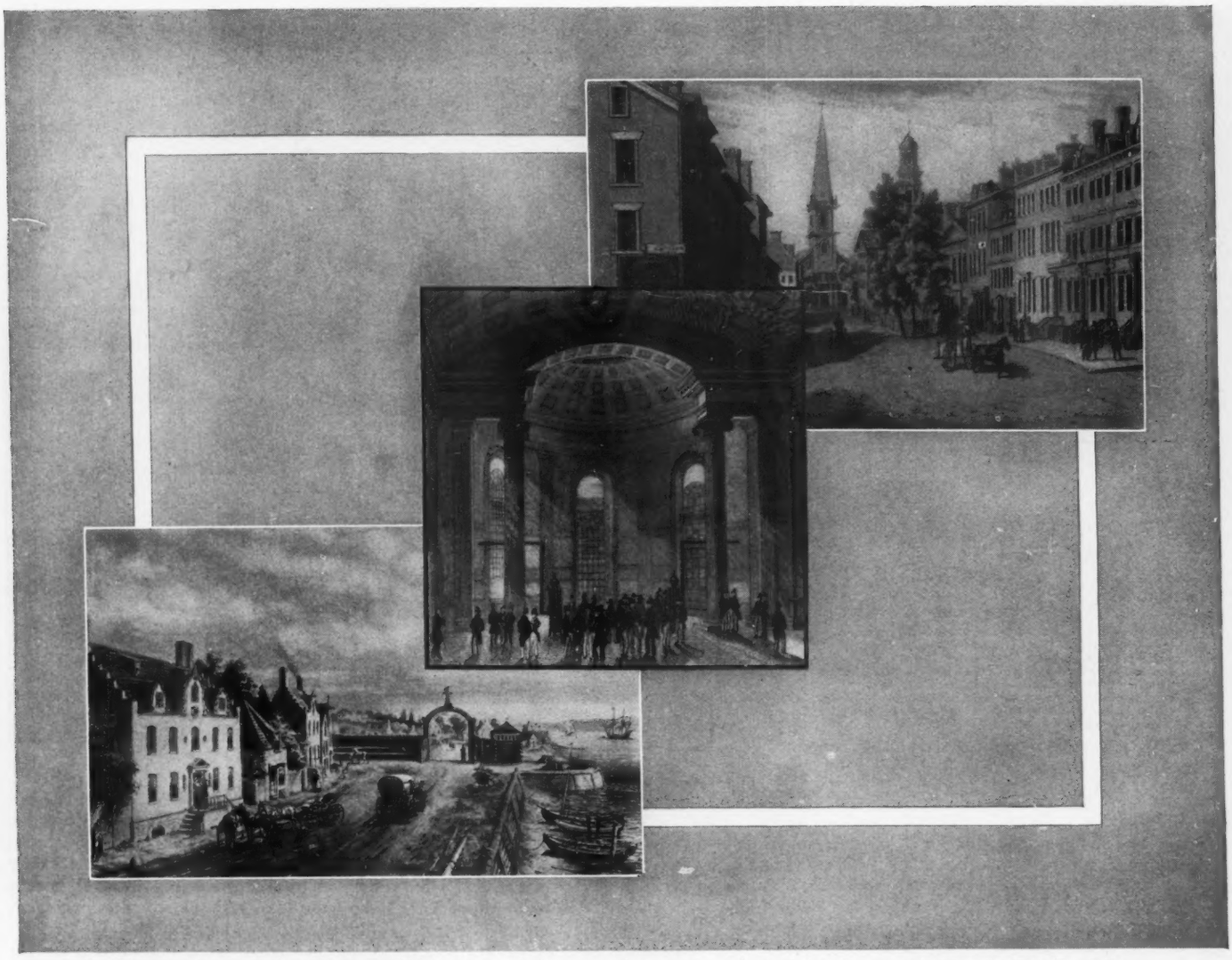
The exterior of the new building is of simple design. The first story is of Mohegan granite. Above this, the steel skeleton is sheathed in white Alabama limestone which possesses the quality of growing whiter with age. A tower rises from the twenty-seventh to the fifty-fourth stories. At the eighteenth floor are fourteen huge heads in stone, representing giants of finance. They are arranged on two sides of the structure in groups of seven each. Flanking each group and set slightly lower down are stone eagles.

The skyscraper provides 600,000 square feet of floor space. The first fifteen floors are devoted to the business of the owning company and its affiliates, The National City Bank and The National City Company. The remaining floors, except two, are rented out as office accommodations. The fifty-first and fifty-second floors are given over to private dining rooms for the senior officers of the three organizations and their business guests.

The entrance doors are of bronze, trimmed with nickel, a combination used, it is said, for the first time in such a building. All the entrances are decorated with medallions and seals in stone—symbols of the modern business world and its evolution. The interior of the first floor is finished in rare marbles and soft-toned woods gathered from many parts of the earth. Examples of the metal worker's art abound in the form of grilles on windows and ventilators and castings for elevator doors and other features.

The following descriptive passages regarding the building are taken from a booklet, *The Oldest Trust Company and Its Newest Home*, which was prepared by the owning company to commemorate the opening of the new structure: "The air that one breathes in this new structure is so treated as to be as pure as is possible. The fresh air is taken in through bronze grilles on the first and ground floors. It is carried to the sub-basement, where the fan room and conditioning apparatus are located. This is literally an 'air laundry.' The air is washed, first through an oil grid, then in a chamber where sprays of water shower continuously. After the air passes through this, it is dried over heating coils, raised or lowered to the desired temperature, and re-humidified. It is ionized by electricity and thermostatically discharged. No outside ventilation is necessary up to the eighteenth floor. Heat and cold control is complete throughout the building. The temperature at any given point can be altered almost momentarily to suit the whim of the most exacting.

"Transportation in this great building is by



Left—Home of the notorious Captain Kidd whose coach house once stood on part of the site occupied by the City Bank Farmers Trust Building. Center—Interior of the Merchants' Exchange which housed the Farmers' Loan & Trust Company from 1827 until 1835. Right—Wall Street in 1822 when the Farmers' Loan & Trust Company was founded.

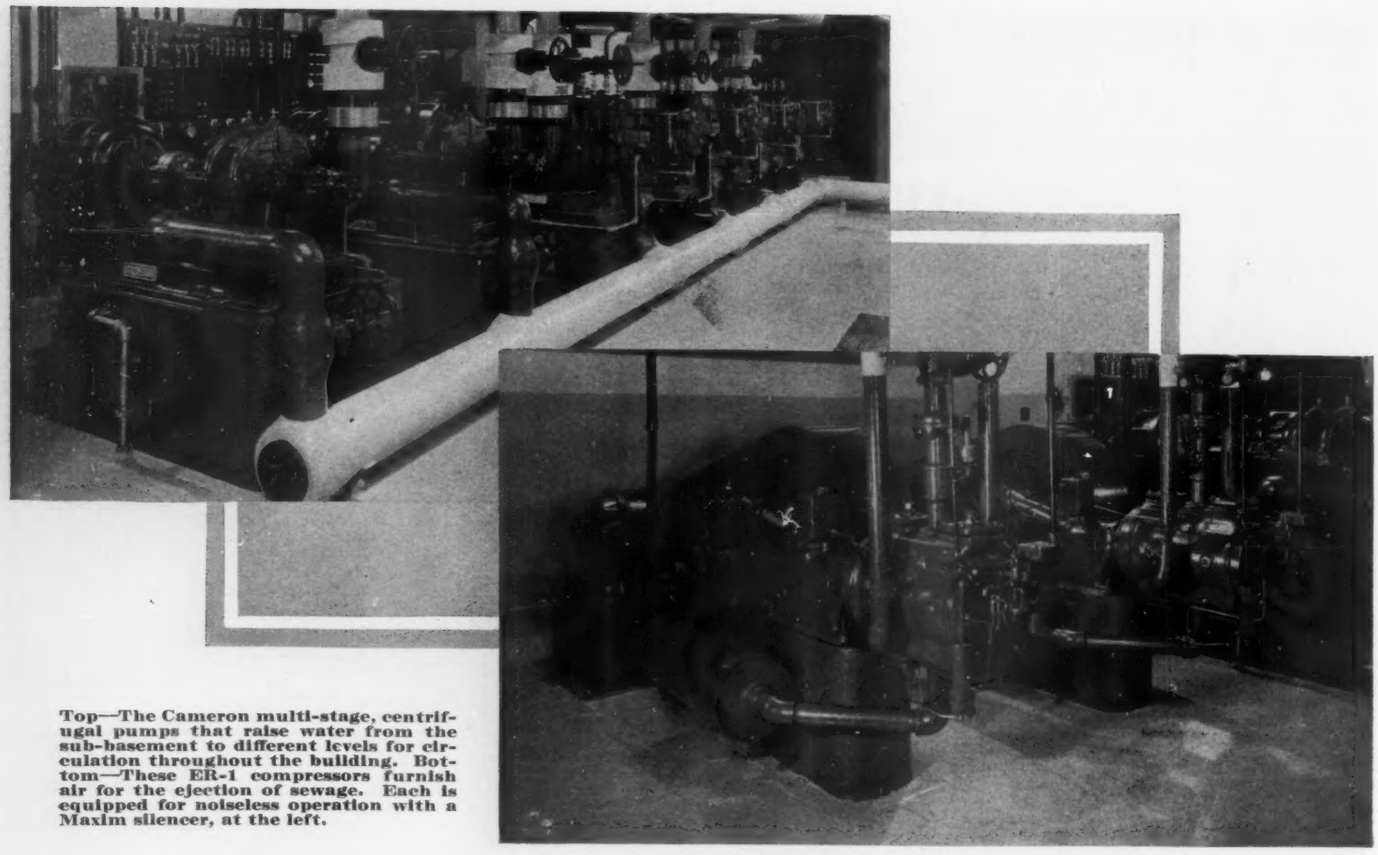
elevators that whirl the rider upward as rapidly as 1,200 feet a minute. Of the four banks of cars on the first floor, 'A' attains a speed of 750 feet, 'B' and 'C' 800 feet, and 'D'—for long hops—1,200 feet. Each bank is finished in a different wood, primavera, pollard oak, lacewood, and rosewood. The doors are similar, each containing two figures representing ascent and descent. Bank 'A' cars have a capacity of 24 persons, 'B' and 'C' 16, and the tower cars—'D' bank—20 persons. Some ascend to the twenty-sixth floor without a stop: others to the tower.

"To link the building with the outside world, a telephone system has been installed that is the largest of its kind in the world. A large part of the fifteenth floor is devoted to an 80-position switchboard and the equipment to operate it. A staff that includes a former official of the New York Telephone Company is constantly on duty. The plant has 10,000 extension lines, 800 central-office trunks, and 800 tielines for direct connection to branches and other firms. When fully equipped, this system can handle a daily total of 39,000 outgoing, 59,000 incoming, and 51,000 interior or inter-office calls. In it are merged the telephone units formerly maintained by the three organizations, The National City Bank, the City Bank Farmers Trust Company, and The National City Company. All interior service and outgoing local calls are made through the dial system. Thus the president can spin a dial and with little delay talk to any one of the far off branches—foreign as well as domestic—of the City Bank and its affiliates.

"The building goes down as well as up. Below the street level are four floors that descend 63 feet, giving the building a total extension of 808 feet from base to summit. The lowest of the basements contains mechanical equipment for vacuum-cleaning, pneumatic-tube, and ventilating systems. The next level is used for storage, and the two others for banking rooms and steel security and book vaults. The three security vaults are protected by every modern safety device. They and the ten book vaults are among the largest in the world."

The operation of such a structure naturally requires a large amount of mechanical equipment to provide the various conveniences and necessities which tenants of high buildings nowadays enjoy. Some of these, such as ventilation and elevator service, have been mentioned. One of the essential requirements which calls for dependable, efficient equipment is that of circulating water throughout the structure. Water from the city distribution mains is under a pressure sufficient to lift it only a few stories, at best. Accordingly, all skyscrapers have to maintain pumping and distribution systems to take care of the needs of the upper floors. This is done by installing tanks at different high levels, with pumps for filling them periodically. Water then flows through the regular piping system for general service of the floors below, pressure being obtained by gravity.

In the City Bank Farmers Trust Building there are three such tanks. At the tip of the tower, at an elevation corresponding to the fifty-sixth-story level, is a 10,000-gallon receptacle. This serves the floors down to the thirty-sixth. Between floors 36 and 37 is a



Top—The Cameron multi-stage, centrifugal pumps that raise water from the sub-basement to different levels for circulation throughout the building. Bottom—These ER-1 compressors furnish air for the ejection of sewage. Each is equipped for noiseless operation with a Maxim silencer, at the left.

tank of 12,700 gallons capacity, which serves the intermediate floors. Between floors eighteen and nineteen is a 10,280-gallon tank which supplies all the floors below that point.

These three tanks are replenished as needed by pumping water from a tank located in the lowest of the sub-basements. The pumps consist of six units—one for each pumping level and a duplicate for auxiliary or standby service. All are Cameron multi-stage pumps of the centrifugal type. Each is connected through a flexible coupling to its driving motor, both pump and motor being mounted on a common sub-base. The six units are installed in a bank adjacent to the tank from which they receive their supply of water.

The pumps are arranged for automatic control. In each of the distribution tanks is a float. When the water is withdrawn to a predetermined level, the float actuates a switch which starts one of the pumps supplying that tank. When the tank has been filled to a certain point, the rising float serves to shut down the pump. This system eliminates the necessity for manual operation of the pumps, although hand control may be employed any time it is desired.

The pumps which fill the lowest of the three tanks are Type EV, 2-stage units of 250 gallons per minute capacity against a 324-foot head. They operate at 1,715 revolutions per minute, and are driven by General Electric Company 40-hp., slip-ring motors using 3-phase, 60-cycle current. The pumps have 2-stage, double-suction-type impellers. The intermediate tank is served by Type HST, 4-stage pumps, each of which has a capacity of 200 gallons per minute against a head of 575 feet. They operate at 1,730 revolutions per minute and are driven by General Electric 60-hp., slip-ring motors. The uppermost tank is supplied by Type HST, 6-stage pumps, each of which has a capacity of 150 gallons per minute against a head of 856 feet. These units operate at 1,760 revolutions per minute and are driven by General Electric 75-hp. motors. All the Type HST pumps have single-suction impellers. Each unit is equipped with a hydraulic balancing drum, supplemented by a Kingsbury thrust bearing. They are of the heavy-duty type designed for high-pressure service such as mine drainage, boiler feeding, etc.

Adjacent to the line of pumps are two Ingersoll-Rand Class ER-1 single-stage air compressors which supply air for the ejection of sewage. Each compressor has a piston displacement of 120 cubic feet per minute. They are driven by short belts from General Electric 15-hp. motors. The intake of each machine is equipped with a Maxim silencer.

Cross & Cross were the architects for the City Bank Farmers Trust Building, and Clyde R. Place was the consulting engineer. George A. Fuller Company had the general contract, and J. L. Murphy, Inc., the plumbing contract, which included the installation of the pumps and the compressors.

Site of the City Bank Farmers Trust Building as it appeared in 1643.

In England and in Hungary, information has it, is being tried out a new method of roadbuilding that had its origin in the latter country and is said to have sufficient merit to warrant large-scale experiments. It consists of spreading a layer of certain kinds of stone over the surface of the highway in the making and of fusing it into a solid mass. This is done by a specially designed furnace.

The furnace is the width of a traffic lane, and is mounted on wheels that run on tracks. It is fired with crude or crude waste oil fed to the burners by compressed air. Traveling over the broken stone, the furnace reduces it to a molten state in from four to five hours. The hot mass is then leveled and allowed to set, which is also effected in from four to five hours.

Unforeseen Benefits of Research

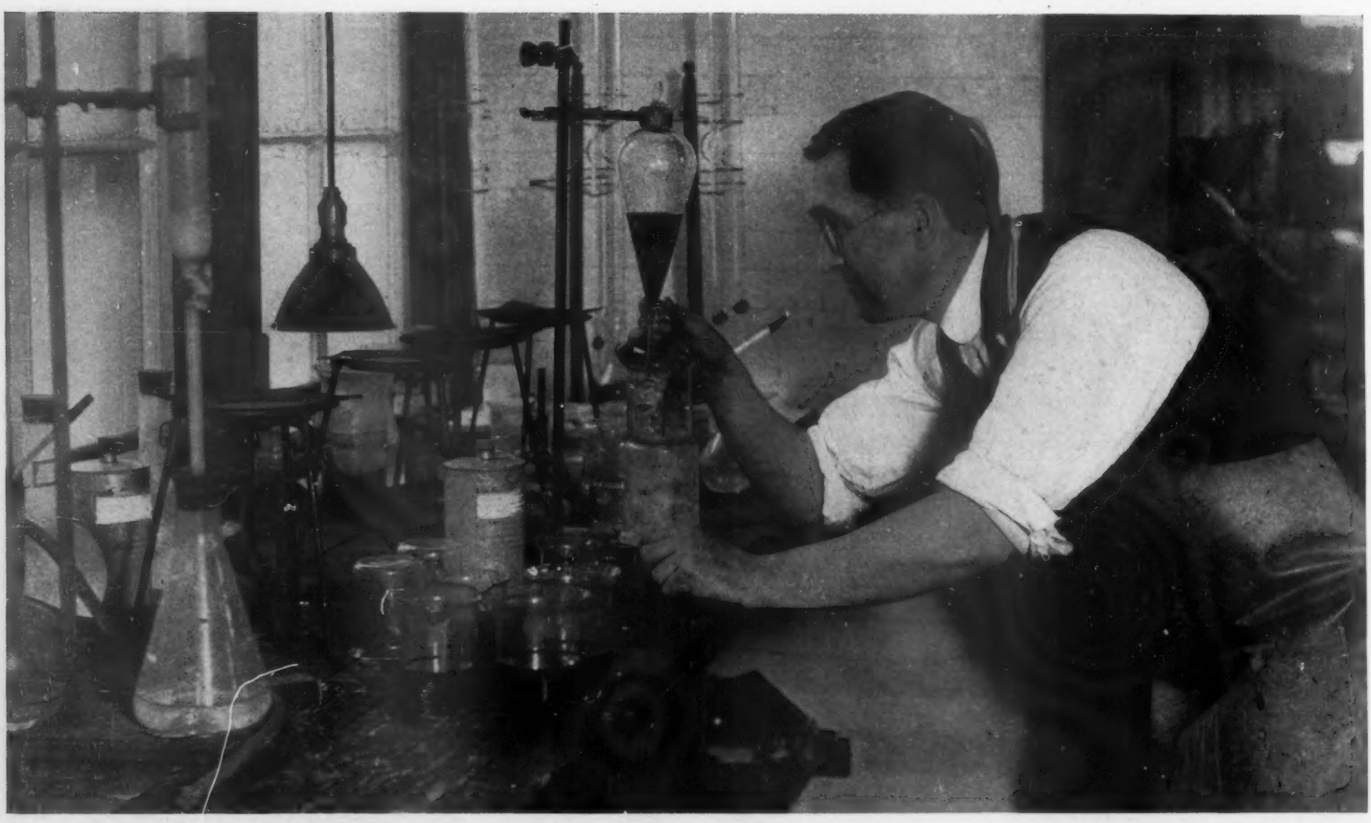
MANY among the practical-minded do not look with favor upon scientific research unless immediate benefits can be realized; and they even insist upon proof of this before they sanction outlays for the work. This is a mistaken attitude, because no substantial progress can be made in any direction without some degree of venturing—and the outcome of research can seldom be predetermined. More than once seemingly unimportant discoveries have led to momentous applications; and a present revelation of no apparent worth may eventually be of the utmost value.

The story we are going to tell hangs upon the unexpected influence of a perfectly commonplace spigot, and how, after a lapse of several decades, the Bureau of Plant Industry of the United States Department of Agriculture profited thereby. Karl Wilhelm von Naegeli, a brilliant Swiss-German botanist, was interested in pursuing the life history of a certain genus of the fresh-water algae, commonly known as "green slime" or "frog spittle"—most of us being familiar with the formation as it appears on more or less quiet or slow-flowing waters.

To the unaided eye, this alga has the appearance of a fine, long, green silk thread. Under the microscope, however, the thread is disclosed as a succession of cylindrical-shaped cells, placed end to end, with spiral bands of green chlorophyll and with the protoplasm and nucleus showing clearly. It is thus easy to see the living cell in operation; and, accordingly, von Naegeli planned to study its vital processes under the microscope in the hope of learning just how those processes take place.

To facilitate him, the botanist prepared aquaria with carefully compounded food solutions such as are required by the genus; but after repeated trials he was unable to get the algae to grow. Then he brought water in from a nearby spring, and the algae grew beautifully. While the reason for the difference in action was a matter of no apparent importance, still von Naegeli, with the scientist's curiosity, desired to know why the algae would not survive in his synthetic solution. After a series of tests and trials he traced the cause to the water coming from a bronze faucet in his laboratory and, finally, discovered that the faucet, itself, was the responsible agent—that is to say, the water passing through the tap took up enough copper from the bronze to kill the algae!

The botanist established, by repeated ex-



periments, that so little as 1 part of copper in 50,000,000 parts of water would cause the green spiral chlorophyll band to contract, turn brown, and, later, induce the death of the cell. His disclosure opened up a new field of study bearing upon the physiological effect of dilute solutions. Von Naegeli's report was considered of scientific interest but not of any practical significance.

Along about 1906, the Bureau of Plant Industry received a letter from a watercress grower in the Allegheny Mountains who sought help in controlling a pest that was destroying his cress. The growing of cress in that region was a fairly well-developed industry, and represented large investments. The Bureau sent a physiologist to look into the trouble; and the pest was proved to be the very frog spittle with which the Swiss-German botanist had experimented. The conditions in the cress ponds so favored the growth of the algae, as well as the cress, that the former virtually smothered the latter. In seeking a remedy, the work of von Naegeli was recalled, and copper sulphate, 1 to 50,000,000 parts, was tried. That small quantity of copper completely destroyed the algae without in any way harming the cress. At a cost of a few cents the pest was easily controlled; and in this way the cress growers were saved many thousands of dollars annually.

The remarkable results obtained in that field of service later suggested that copper might be used to check other forms of algal infection of city and town water supplies. Certain algal growths make the water in large city reservoirs well-nigh unusable at times, causing not only great inconvenience but great loss. After investigation, it was found that all these pests could be eliminated at small expense and with absolute safety to the consumers. Besides leading to a saving of many millions of dollars yearly, it was thus possible to add to the health of those who utilized the water. Subsequently, hundreds of water-supply systems were cleaned up in this manner both in the United States and in other parts of the world.

During the foregoing research work it was ascertained that the larvae of certain species of mosquito could be destroyed by the copper treatment that proved fatal to algal growth. A method of killing these pests was, therefore, at hand—one that could be used in water supplies whenever it was not practicable to employ oil. The same means of protection served with great success during a yellow-fever outbreak in New Orleans, and was utilized during the construction of the Panama Canal.

While the experimental investigations leading to the foregoing effective applications were underway, it was observed that some kinds of bacteria—microscopic plants—were also destroyed by dilute solutions of copper. Careful studies were therefore made of the effect of copper on pathogenic species like those causing typhoid fever, paratyphoid fever, and Asiatic cholera. It was established that they were highly sensitive to copper, and that they could be cleared out of a water-supply system as easily as algae without any danger to the users provided the copper was properly applied. The procedure has become standard in sanitary engineering.

As an outcome of that helpful work, chlorine was similarly standardized and developed so that it could be employed in dealing effectually with infected water. The copper treatment has been used in India, China, and the Philippines for disinfecting supplies contaminated with the organisms of cholera and dysentery. The value of this service is beyond computation; and it may fairly be said to be the outgrowth of von Naegeli's original investigations. If von Naegeli had not asked the question: "Why do my algae die?" and worked till he found the answer, we might never have had the knowledge we now possess. Who could have foreseen such practical benefits from the inquisitiveness of a scientist dealing with green slime? Thus research brings about unexpected benefits.

ROCK-DUSTING GUIDE

THE effectiveness of rock-dusting in collieries depends upon the presence at all times of a sufficient volume of the incombustible material either to prevent an explosion or to localize it. For the purpose of determining when it is time to redust, a German has invented an instrument that was described at the last annual meeting of the North of England Institute of Mining and Mechanical Engineers.

The apparatus measures the tints of samples of dust taken at random from the workings, and compares these with a "scale of grayness". With this factor known. the percentage of rock dust contained in the several samples can be established by referring to a standard table or curve. It is thus possible to keep check on existing conditions and to make certain whether they are safe or not.

U. S. Bureau of Reclamation

Area immediately above the Hoover Dam site, seen from Monument Pass, Nevada, that will form part of the vast reservoir which is to hold more than 30,000,000 acre-feet of water.

America's Wonder River—the Colorado

*Work on the Hoover Dam Now Underway After the Disposal of Many Puzzling Questions**

By R. G. SKERRETT

IN curbing the Colorado by means of the Hoover Dam, the Federal Government is essaying the greatest task in hydraulic engineering that it has taken upon itself since digging the Panama Canal. In beginning this momentous undertaking, both engineers and constructors have joined battle with inexhaustible nature; and they have willed to bring under subjection a stream with a violently riotous record that reaches unbrokenly into the dim past. The work in hand is not only superlatively big in the matter of dimensions but vast in its economic potentialities and significance.

The mere start of the Hoover Dam crystallizes agitation for the control of the Colorado that dates back more than a quarter of a century. And that we may have a fair conception of the undertaking and the steps by which it has been brought to its present pass, it might be well to summarize the preliminaries that smoothed out difficulties of various sorts and that provided a firm basis for the consummation of a long-desired relief.

The Hoover Dam project as now planned calls for the ultimate expenditure of $165,000,000, including the construction of an appurtenant undertaking known as the All-American Canal. The total sum will be made up of the following four items:

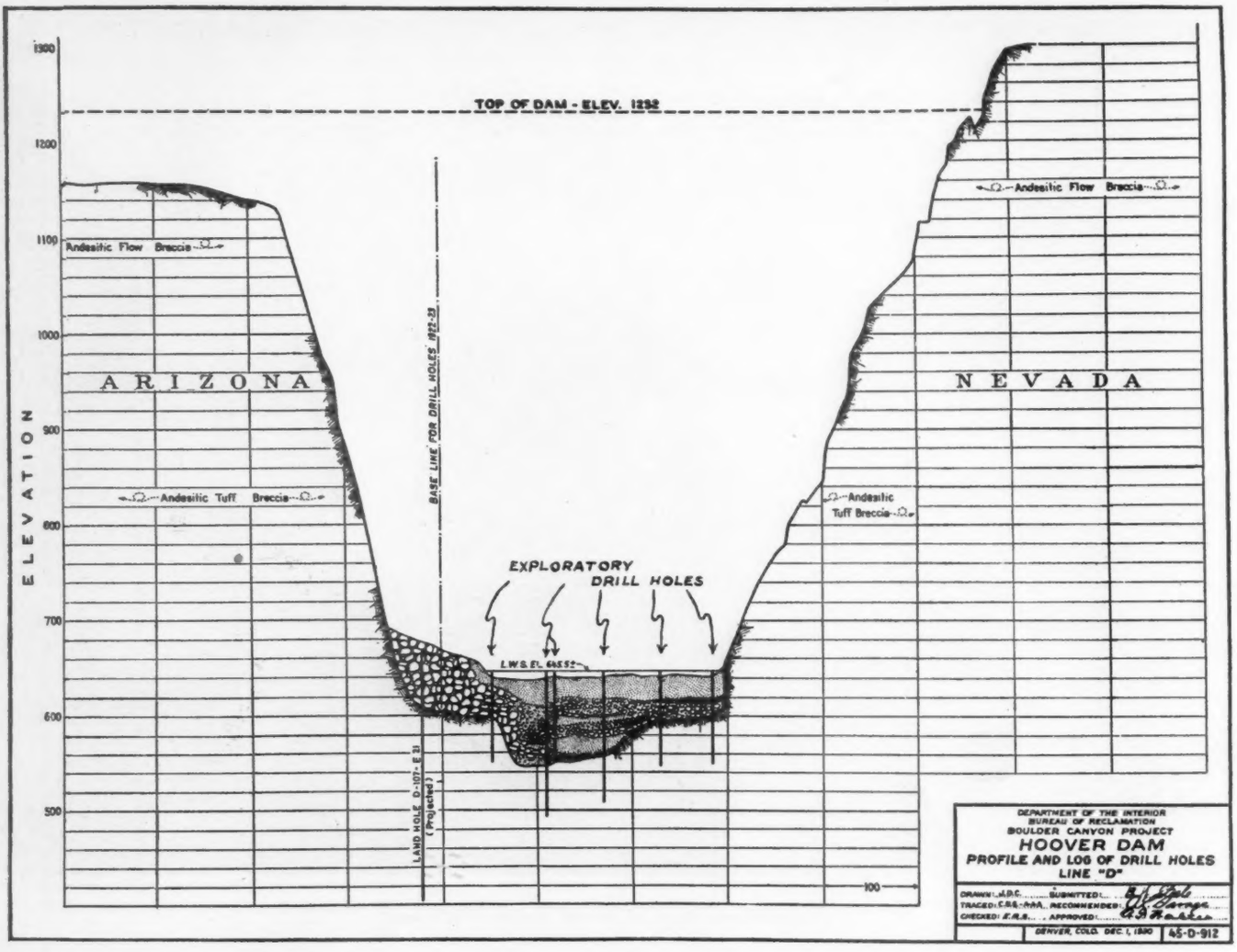
Dam and reservoir	$70,600,000
1,000,000-hp. development	38,200,000
All-American Canal	38,500,000
Interest during construction	17,700,000
Total	$165,000,000

The All-American Canal will, when completed, take water from the Colorado at a point above the Mexican boundary, and is designed to supply the needs of the Imperial Valley and the Yuma project. It will be 75 miles in length, and will be notable for a number of reasons. We shall not now touch upon this phase of the control of the Colorado River—the matter of immediate interest is the Hoover Dam and its associate features.

Colorado River Compact

The building of the Hoover Dam might still be something for future decision had not the Colorado River Commission been called into existence in 1921. That commission was made up of representatives from Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming. Herbert Hoover, then Secretary of Commerce, was the chairman of the commission. The commission was brought into being when the several states immediately concerned had advanced numerous sincere but very conflicting claims; and it was manifest that some representative body would have to take all these claims under consideration

**Third of a series of articles on the Colorado River and the building of Hoover Dam.*



Black Canyon before work was started on the Hoover Dam project. The site is just at the far bend in the river and was chosen only after extensive investigation had revealed its outstanding advantages.

U. S. Bureau of Reclamation

and, if possible, bring about accord. The compact adopted at Santa Fe, N. Mex., on November 24, 1922, bears testimony to the broad-minded spirit of give and take that actuated the commissioners and enabled them to arrive at a happy understanding within a period of less than a year. Never before had more than two states thus adjusted their contending claims; and the compact is, therefore, of unusual significance. Mr. Hoover's tact, patience, diplomatic persuasiveness, and recognized engineering skill had much to do in promoting the outcome.

The commission earnestly recommended and urged the early construction of works in the Colorado River to control floods and permanently to avoid that menace. Before actual steps could be taken to that end, however, certain practical questions had to be settled. It was evident that Congress could not be asked to appropriate funds until the best site for a suitable dam were chosen and the size and the cost of such a structure predetermined. Indeed, conclusive information was lacking about some of the canyon sections of the river where it might be found desirable to erect the controlling dam. Accordingly, experts of the United States Geological Survey were detailed to make the needful examinations and to gather certain indispensable hydrographic and geologic data.

Because of physical and climatic conditions, the far-flung region traversed by the Colorado River system may properly be divided into three distinctive sections. The river basin or watershed formed by parts of Colorado, New Mexico, Utah, and Wyoming lends itself to the utilization of the stream's water for irrigation and for power development in about equal divisions. The middle area contiguous to the river largely consists of a 500-mile, high-walled canyon region—the stream dropping a total of about 3,000 feet in that distance. Throughout this area but very little water drains into the Colorado. Plainly, the canyon section is outstandingly a source of potential power and virtually unable to make more than extremely small use of the river's water for irrigation. The lower reaches of the Colorado, lying in the southern half of Arizona and the southeastern part of California, constitute an area of 69,000 square miles; and while the river throughout this region drops about 500 feet in 300 miles still it is preëminently suited to agricultural operations. Thus, it is manifest that the Colorado River Commission did wisely in dividing the whole watershed into two main divisions or basins. The Upper Basin embraces parts of Arizona, Colorado, New Mexico, Utah, and Wyoming lying above Lees Ferry, while the lower Basin is composed of those parts of Arizona, California, Nevada, New Mexico, and Utah below Lees Ferry.

The natural flow of the Colorado River averages annually 20,000,000 acre-feet; and about one-third of this flow is now utilized. Present users in the Lower Basin take about 3,700,000 acre-feet. By the compact, this region is awarded a total yearly flow of 8,500,000 acre-feet—more than double existing needs. The Upper Basin was awarded 7,500,000 acre-feet, also more than double its present needs and ample to serve quite 3,000,000 acres of additional cultivated land. Besides these allotments, there remains an unapportioned measure of 4,000,000 acre-feet of water for future division as unforeseen demands may arise. So much for the wise and equitable apportionment of the water made by the commission.

Choice of Dam Site

The steep gradient of the Colorado in the canyon section made logical the building of a control dam therein. The problem then was to find the place within that section where physical conditions would lend themselves best to the rearing of such a structure and where such a structure would be able to impound the largest volume of water. Furthermore, the dam had to be so situated that the associate power plants would be within relatively easy reach of markets for the electricity generated there. Consideration had to be given to the distances within which current could be transmitted without encountering prohibitive losses. The importance of this phase of the problem becomes apparent when it is realized that the sale of power is counted upon to repay the outlays incident to the building of the Hoover Dam. Indeed, the undertaking would probably not have been started had this method of refunding not been assured by contracts made with prospective users.

The responsibility for the choice of the dam site was placed upon the Colorado River Board on the Boulder Dam Project. The board was called into being agreeably to a joint resolution of Congress approved May 29, 1928. It was composed of eminent engineers and geologists; and its report was made towards the end of November following. Two sites were considered—one in Boulder Canyon and one in the upper part of Black Canyon; and the Black Canyon site was chosen. The reasons for the selection are thus summed up by that body:

"In general, geologic conditions at Black Canyon are superior to those at Boulder Canyon. The Black Canyon site is more accessible, the canyon is narrower, the gorge is shallower below water level, the walls are steeper, and a dam of the same height here

would cost less and would have a somewhat greater reservoir capacity. The rock formation is less jointed, stands up in sheer cliffs better, exhibits fewer open fractures, is better healed where formerly broken, and is less pervious in mass than is the rock of the other site. The Black Canyon rock is not so hard to drill as that of Boulder Canyon; and it will stand better in large tunnel excavations with less danger to the workmen.

"There is no doubt whatever but that the rock formations of this site are competent to carry safely the heavy load and abutment thrusts contemplated. It is well adapted to making a tight seal and for opposing water seepage and circulation under and around the ends of the dam. It insures successful tunneling, and, so far as the rock is concerned, the general safety and permanence of the proposed structures." Exploratory drilling, carried to a depth of 557 feet below the low-water surface of the rock, did not penetrate any other formation.

While the foundation rock upon which the dam will rest is a volcanic breccia or tuff, derived from probably repeated eruptions, still time has worked a transformation that has cemented the breccia into a tough, durable mass of rock capable of withstanding the weather and of resisting erosion exceptionally well. There is every indication that volcanic action ceased thousands of years ago; and the district, today, is virtually free from the effects of recurrent earth movements in that part of the country.

The board realized that the dam then contemplated would have to be much higher than any other dam built or projected, and was keenly alive to the fact that the structure would have to be correspondingly strong. Failure would let loose suddenly an enormous body of water which, sweeping unimpeded down the river channel, would probably destroy Needles, Topock, Parker, Blythe, Yuma, and obliterate the levees of the Imperial district—creating a channel into the Salton Sea that would in all likelihood be so deep that it would be impracticable to turn the Colorado River again into its normal course. As the board expressed it: "To avoid such possibilities the proposed dam should be constructed on conservative if not ultraconservative lines." That recommendation has been observed in every phase of the design of the Hoover Dam.

What the Dam Must Do

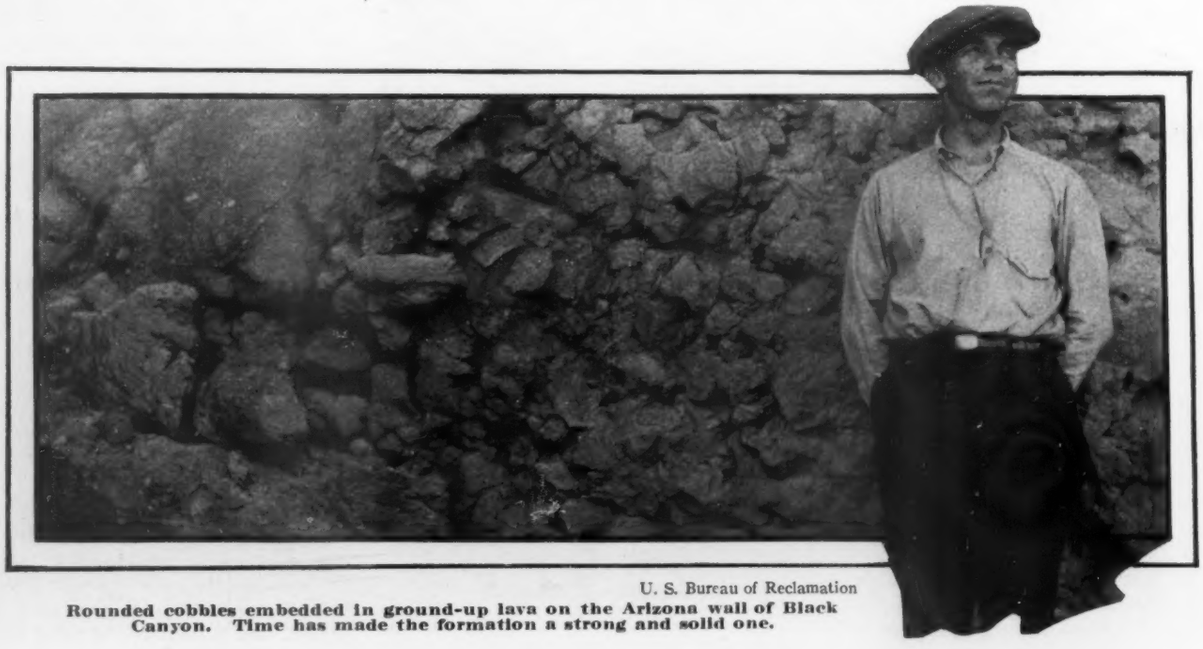
The Hoover Dam may best be described as a titanic wedge of concrete that will be rigidly secured to the rock underlying the normal water bed and anchored to the towering flanking walls of the relatively narrow gorge. From base to crest the structure will have a height of 730 feet; and up and down stream the base will have a spread of 650 feet. Along the crest the dam will have a width of 45 feet and a length of about 1,180 feet; and it will be made up of substantially 3,500,000 cubic yards of concrete. The foundation will be bound to the supporting bedrock at a depth of 150 feet below the low-water level of the river. Expressed otherwise, the dam will replace rock worn away by the Colorado in its age-old rush seaward.

The function of the dam is a fourfold one: It is to serve for flood control; for the regulation of irrigation flow; for the development of power; and for the storage of silt. The basin created by the Hoover Dam will have a capacity of 30,500,000 acre-feet of water, or water enough to cover to a depth of 1 foot the combined land areas of Maine, New Hampshire, and Vermont. The lake above the dam will extend upstream for a distance of 115 miles and at its widest point have a breadth of eight miles. It will be the biggest of man-made reservoirs, and will be able to store nearly seven times as much water as the world-famous Assuan reservoir, on the Nile, after the heightening of the Assuan Dam has been completed. Expressed in another way, the Hoover Dam basin will have sufficient capacity to hold substantially a two years' flow of the Colorado!

Annual Flow of River

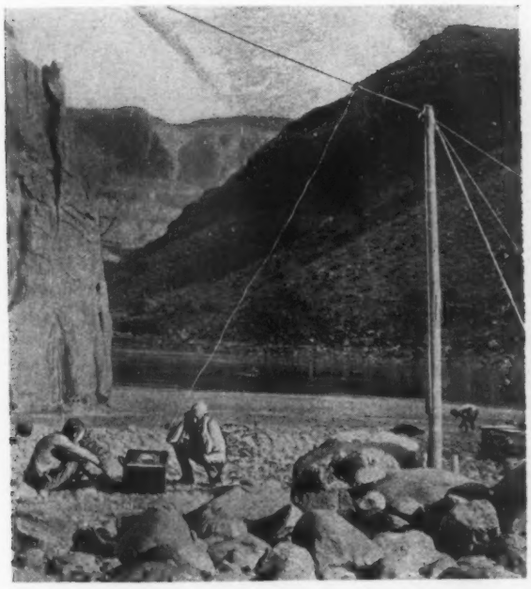
Averages are difficult to arrive at in the case of the Colorado's flow. At times the discharge is less than 3,000 second-feet, while on one recorded occasion the outpouring mounted as high as 300,000 second-feet! Careful records made over a period of some years have given an average annual flow of 17,300,000 acre-feet. The point to be emphasized is that the Colorado in any of its flood periods presents a problem for the hydraulic engineer; and the Hoover Dam has been so designed that it can stand rigidly, with a very large factor of safety, against on-rushing torrents when the river is in a tempestuous mood. When the water is at its maximum height in the lake it will have a depth of 580 feet.

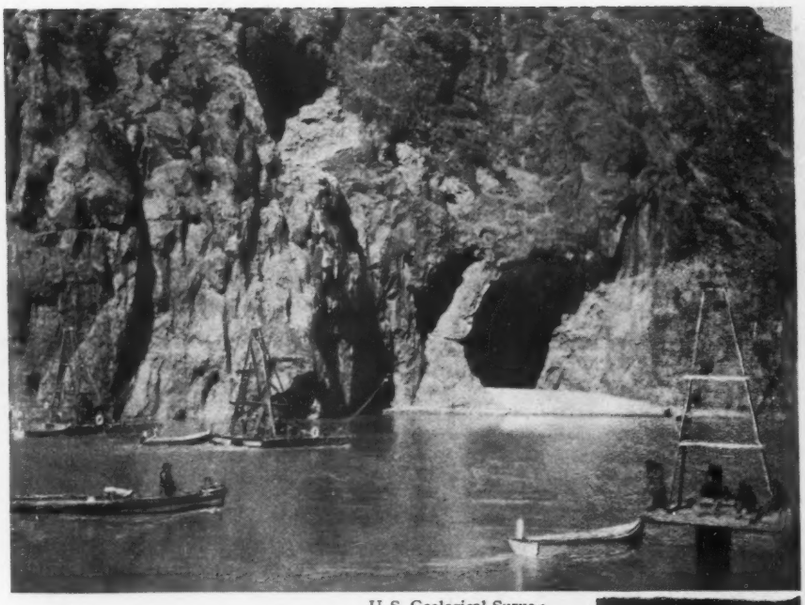
Next to controlling the flood flow of the Colorado, the reservoir created by the Hoover Dam will, because of its stupendous capacity, make it feasible to release continually into the river channel a volume of water ample enough to meet the irrigation needs of the farmlands on the Yuma project, in the Imperial Valley, and on those lesser areas in the lower reaches of this variable stream. So much stress has been laid upon flood control and the ravages wrought by the river when on its annual rampages that most people unfamiliar with the Colorado assume that it always is of sufficient volume to meet the demands of dependent agriculturists. This is not true; and there are years when there is an actual deficiency in vitally necessary water. Therefore, the conservation and control which will be made possible by the completion of the Hoover Dam will prevent these serious fluctuations and assure, from season to season, the water that may be required for the growing of crops and other essential purposes. The foregoing services are the primary ones of this magnificent project. Now let us consider briefly the two remaining objects of the undertaking—one of which is to make the venture a self-paying proposition.



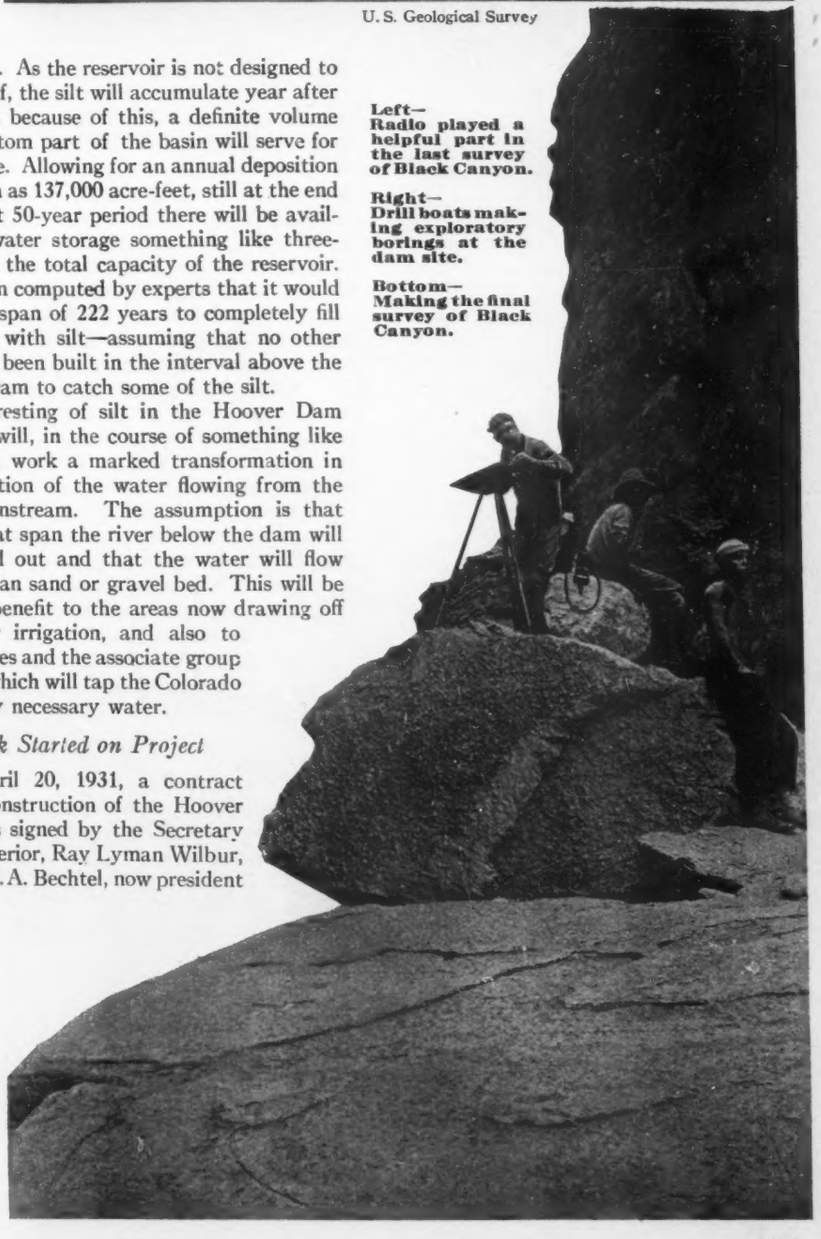
U. S. Bureau of Reclamation

Rounded cobbles embedded in ground-up lava on the Arizona wall of Black Canyon. Time has made the formation a strong and solid one.





U. S. Geological Survey



Left—
Radio played a helpful part in the last survey of Black Canyon.

Right—
Drill boats making exploratory borings at the dam site.

Bottom—
Making the final survey of Black Canyon.

Generation of Power

Associated with the Hoover Dam will be power plants equipped with groups of great hydro-electric generators that will have a combined rated output of 1,000,000 hp.—one-fourth of all the power that might be developed by a series of stations placed at strategic points in the canyon section of the Colorado. The turbines will be operated under an average head of 520 feet, and they will have a firm or continuous output of about 660,000 hp. The price of this firm power will be at the rate of 1.63 mills per kilowatt-hour. During periods of high water, when the operating head may be as much as 582 feet, the dynamos will generate their full power; and this seasonal current will be sold for 0.5 of a mill for each kilowatt-hour. Cheap power will be a great boon to industrial activities of all sorts, and especially to mining enterprises in California, Arizona, and Nevada lying within a radius of economical distribution.

As Dr. Elwood Mead, Commissioner, Bureau of Reclamation, has pointed out: "The power and water income from the contracts already signed will, in 50 years, bring an income of $373,500,000. Of this, the United States will receive $228,260,000 to repay money advanced, with interest. Arizona and Nevada will each receive $31,235,000; operation and maintenance will absorb $16,120,000; and there will be a surplus of $66,650,000, which will be the net profit of the Government for going into this enterprise. This sum will be disposed of as Congress may hereafter direct." This statement will answer the questioning taxpayer.

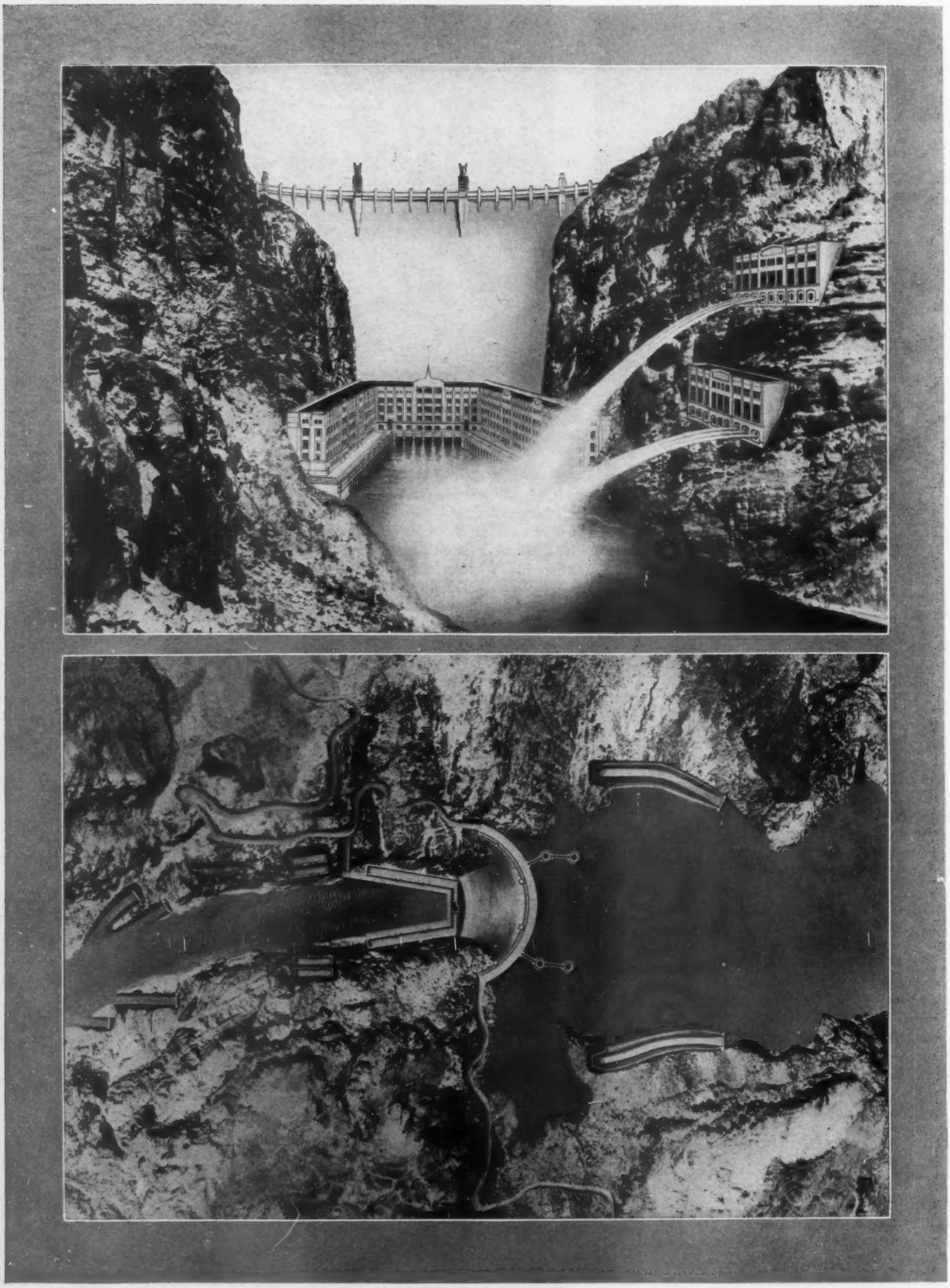
Storage of Silt

As had been well and wittingly said, the Colorado when in flood is a stream too thick to drink and too thin to plow. This description is based on the fact that the river will pour into the Hoover Dam reservoir approximately 100,000 acre-feet of mud every twelve-month; and the major part of this alluvium will find a resting place on the bottom of the vast basin. As the reservoir is not designed to purge itself, the silt will accumulate year after year; and, because of this, a definite volume of the bottom part of the basin will serve for silt storage. Allowing for an annual deposition of as much as 137,000 acre-feet, still at the end of the first 50-year period there will be available for water storage something like three-fourths of the total capacity of the reservoir. It has been computed by experts that it would require a span of 222 years to completely fill the basin with silt—assuming that no other dams had been built in the interval above the Hoover Dam to catch some of the silt.

The arresting of silt in the Hoover Dam reservoir will, in the course of something like ten years, work a marked transformation in the condition of the water flowing from the dam downstream. The assumption is that within that span the river below the dam will be cleared out and that the water will flow over a clean sand or gravel bed. This will be of great benefit to the areas now drawing off water for irrigation, and also to Los Angeles and the associate group of cities which will tap the Colorado for vitally necessary water.

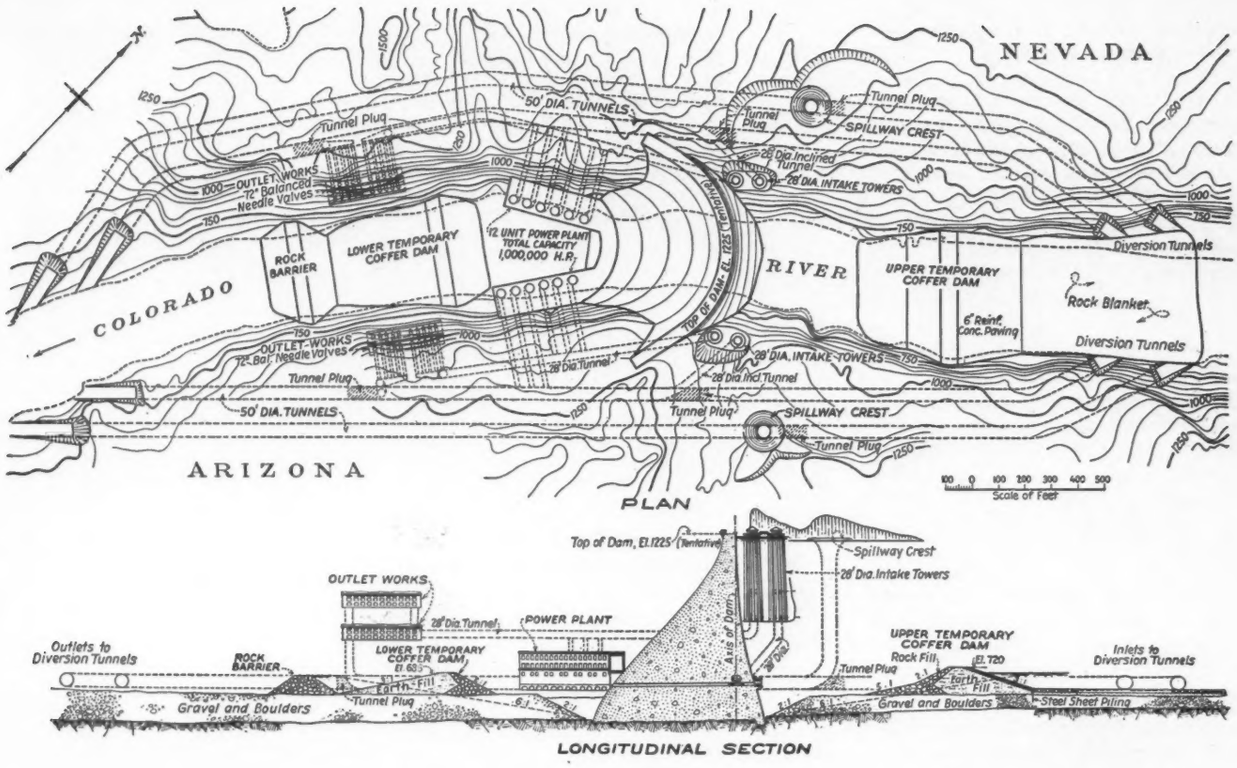
Work Started on Project

On April 20, 1931, a contract for the construction of the Hoover Dam was signed by the Secretary of the Interior, Ray Lyman Wilbur, and by W. A. Bechtel, now president



U. S. Bureau of Reclamation

Top—How Hoover Dam and its appurtenant power plant will look when ready for service. Bottom—Model of Hoover Dam and its associate features. The lake created by the dam will be 115 miles long and capable of impounding a maximum of 30,500,000 acre-feet of water.



of the Six Companies Incorporated. Six Companies Incorporated contracted to build the Hoover Dam, the power plant, and certain associate works for the sum of $48,890,995. That act brought to a close long years of waiting and, to that extent, relieved the anxieties of our people in the lower sections of the river where there has been an ever-recurrent fear that the Colorado would break loose and overrun and ravage the contiguous cultivated lands.

With the project actually underway, it is now possible to look backward and to realize that much has probably been gained by delay. Both the engineers responsible for the present magnificent scheme and the contractors engaged in carrying it out are richer in their knowledge and their experience than they would have been had they tackled a task of like proportions twenty years ago. Also, makers of machinery have, in the intervening decades, devised equipment of different kinds especially fitted to deal effectually and rapidly with the heavy and complex work involved. The contractors are called upon to rear a mountainous obstruction athwart the erratic flow of the Colorado and, at the same time, to divert that stream temporarily around this rising bulwark no matter what may be the state of the stream the while!

What the Contractor Must Do

The Hoover Dam site is about 25 miles southeast of Las Vegas, Nev., and situated in what was an utterly isolated desert region before steps were taken to provide means of transportation from the nearest railroad and to create accommodations for the army of workers that will be engaged on the job for quite 6½ years—the period during which Six Companies Incorporated pledges itself to complete its part of the great undertaking. Interesting as it would be to tell how these preliminaries were carried out and how a sizable town—Boulder City—was called into being in the midst of that hot and arid region, space compels us to confine ourselves strictly to the work involved in connection with the dam and its immediately appurtenant features.

Before any part of the dam can be started, the contractor must drive four tunnels which will be 56 feet in diameter and average more than 4,000 feet in length. Two of these are being driven on the Nevada side of the Colorado and two on the Arizona side—the tunnels piercing the rock at an elevation close to that of the low-water level of the river. These tunnels are counted upon to carry the entire volume of the flow at any likely stage. Upstream above the dam site, and just below the intake ends of the tunnels, a great cofferdam, 80 feet in height, will be constructed. This will block the normal course of the river and divert its flow into the diversion tunnels. Just upstream from the outlet ends of the tunnels, and below the dam site, will be built another massive cofferdam that will prevent the Colorado from encroaching upon the space between the two cofferdams. This space will be unwatered so that the river bed can be bared preparatory to removing the accumulated sand and gravel down to bedrock, from 80 to 100 feet below the low-water level. The excavation for the foundation of the dam will necessitate the removal of substantially 7,000,000 cubic yards of material.

In driving the diversion tunnels, which, with the cofferdams, will be completed in about two years, the contractor will drill, blast, and muck nearly 2,000,000 cubic yards of rock. Something like three-fourths of this rock will be used to stabilize the two cofferdams. With the cofferdams built and with the tunnels driven and lined with 3 feet of concrete, the contractor can start work on the dam itself, and he will then bring into play a multiplicity of facilities that he has been making ready and assembling in the meanwhile. As time goes on, it is our purpose to keep our readers posted on the progress of the work, and, therefore, we shall not confuse by entering into details now.

The building of the Hoover Dam involves a battle with climatic conditions that are extremely severe and trying during the warm months of each year. Again, we quote Doctor Mead: "The summer wind which sweeps over the gorge from the desert feels like a blast from a furnace. At the rim of the gorge, where much of the work must be done, there is neither soil, grass, nor trees. The sun beats down on a broken surface of lava rocks. At midday, they cannot be touched with the naked hand. It is bad enough as a place for men at work. It is no place for a boarding house or a sleeping porch. Comfortable living conditions had to be found elsewhere, and these are found on the summit of the Divide, five miles from the dam. Here there is fertile soil; here winds have an unimpeded sweep from every direction; and here there is also an inspiring view of deserts and lonely gorges and lofty mountain peaks."

When the dam is an accomplished fact, when the pent-up waters are available for controlled irrigation and for the generation of power, then that amazing structure will constitute a milestone for a civilization under which unnumbered generations will flourish. A vast new empire of industry and enterprise will center upon that towering monument to engineering skill and to the never-failing resourcefulness of the men responsible for its consummation.

INTERNAL-COMBUSTION ENGINES FOR LIGHT DUTY

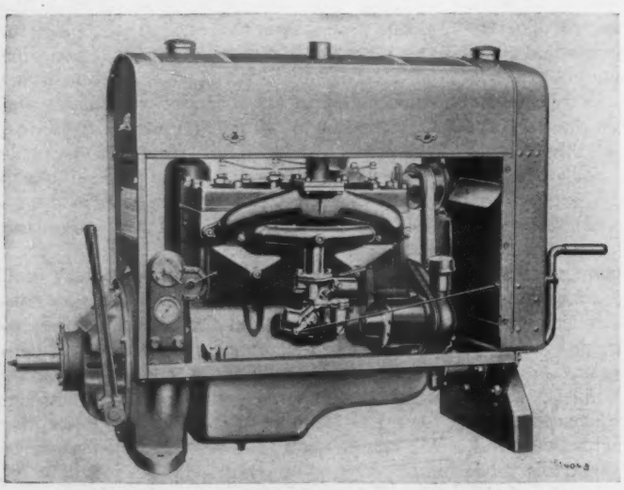
THE Waukesha Motor Company, well-known makers of heavy-duty, internal-combustion engines, has entered a new field in the industrial engine market through the manufacture of small 4-cylinder engines with capacities ranging from 10 to 20 hp. The "Agile Four", as the new units are designated, have been built to fill the demand for engines under 20-25 hp., which have heretofore not been available.

These small Waukesha engines have all the earmarks of their bigger brothers. They have the standard Ricardo combustion chamber; short, stiff crankshaft supported by three exceptionally large bronze-backed replaceable bearings; full-pressure oiling system; built-in governor; and detachable flywheel housing. In addition to these typical Waukesha features, the "Agile Four" are said to offer an unusual degree of flexibility in the matter of mounting such accessories as a full-series-type oil filter, complete electric starting and lighting system, 3-point suspension, and either battery or magneto ignition, all of which are readily available.

The full-pressure oiling system, with drilled crankshaft and outside pressure adjustment, is not commonly found in small engines. The lubricant is distributed by a positively driven gear pump submerged in the oil reservoir and surrounded by the Waukesha patented oil-level equalizer. This insures a constant supply of lubricant under full pressure at all levels and temperatures.

For outdoor use, a self-contained power unit can be had. Bolted to a pair of 4x4-inch skids, it can be easily moved from place to place and quickly set to work the same as an electric motor. The power take-off is entirely enclosed, and a substantial sheet-steel housing protects the engine from the weather.

The new Waukesha engines weigh close on to 300 pounds. They have many fields of use, among them the operating of plaster and concrete mixers, of golf-course rollers, and of high-pressure sprayers.



Small-size Waukesha internal-combustion engine encased for outdoor use.

AFRICA UNVEILED, by Owen Letcher. An illustrated book of 152 pages, published by the author and printed by Waterlow & Sons, Ltd., London. Price, five shillings.

AFRICA will long remain to most of us a land of mystery and of almost unbelievable happenings. The author has merely strengthened this world-wide belief by the stories he has told in a typically gripping manner. In a foreword, the Hon. H. U. Moffat, C.M.G., Prime Minister of Southern Rhodesia, states: "The Africa of which he writes is neither that of the tourist visitor nor of the lady novelist. It is the real Africa, beautiful, mysterious, and wonderful—old, so old, yet ever new. Perhaps it is the meeting and mingling of ancient and modern, barbarism and civilization, of realism and romance that gives to Africa its charm. It is from these varied conditions that Mr. Letcher finds the material for his pictures of life and death in Africa, which are of such absorbing interest."

SHIP MODEL MAKING, Volume II, by E. Armitage McCann. A profusely illustrated volume of 150 pages, published by the Norman W. Henley Publishing Company, New York. Price, $2.50.

THE previous volume of these interesting books dealt with models of Spanish galleons and of Barbary pirate ships. The present one tells how to build in miniature an American clipper ship, and therefore comes that much closer to the heart of a native craftsman. The avocation or diversion of ship-model making is a test of patience, nimble fingers, and constructive aptitude. Any boy or man given to this form of work will find in it both a source of pleasure and, possibly, of profit. There is no surer way to make a person sea-minded than to have him fashion miniature ships and to familiarize himself with the purpose of every feature of their somewhat complicated get-up. Captain McCann has made it comparatively easy for the amateur to master the principles of the art.

THE COURSE AND PHASES OF THE WORLD ECONOMIC DEPRESSION. A book of 337 pages, published by the Secretariat of the League of Nations, and obtainable in the United States from the World Peace Foundation, 40 Mt. Vernon Street, Boston, Mass. Price, $3.00.

THIS report, which has been prepared by Professor Ohlin, of the University of Stockholm, Sweden, deals with a good many outstanding departments of international economic relations that have been affected by or been influential in bringing about the present world depression. It is not possible here to analyze the findings presented in the report other than to say that the volume contains a wealth of authoritative facts and figures that are highly illuminating and which indicate in general terms the dangers that must be avoided by financial leaders seeking to steer a course that will lead them again to the open sea of prosperity.

WHAT THE FIGURES MEAN, by Spencer B. Meredith. A book of 77 pages, published by the Financial Publishing Company, Boston, Mass. Price, $1.50.

THE data in this book are based upon figures available at the close of 1929; and the ratios given have been computed from figures obtained from sources of recognized responsibility. The articles in this volume are designed to help one to read intelligently any financial statement. From time to time, everyone who has dealings with corporations or who is interested in their securities has occasion to go over balance sheets and income accounts. A great many people find it difficult to interpret correctly the information therein presented. When one knows what the figures mean, then it is possible to arrive at a satisfactory basis for good business judgment. This little book will aid to that end.

Industrial Machinery, 1930. Trade Promotion Series, No. 111, issued by the United States Department of Commerce, and obtainable from the Superintendent of Documents, Washington, D. C. Price, 15 cents. This bulletin has been prepared by W. H. Rastall, Chief of the Industrial Machinery Division of the Department of Commerce; and this authority points out that machinery has come to play such an important part in the industrial life of the world that the degree of activity in the machinery industry provides a reasonably accurate barometer of business in general. This is understandable when we grasp the fact that the annual world consumption of machinery now reaches the enormous total value of $5,500,000,000. Of this amount the United States accounts for $2,500,000,000, which means that there is installed each year for every man, woman, and child in this country $23 worth of machinery. The per capita machinery consumption of Great Britain amounts to $10; that of Germany $9; while the figure for India is only 17 cents and that for China 5 cents.